1

AIR FORCE LOGISTICS MANAGEMENT CENTER

AD-A154 203

Proceedings of the USAF

Logistics Capability Assessment Symposium

LOGCAS 82

15-19 March 1982

USAF Academy, Colorado

AIR FORCE LOGISTICS MANAGEMENT CENTER
GUNTER AFS, AL. 36114

PII Redacted

LOGISTICS CAPABILITY ASSESSMENT
SYMPOSIUM
82

Proceedings of the USAF

Logistics Capability Assessment Symposium

LOGCAS 82

15-19 March 1982

USAF Academy, Colorado

AFLMC Report 781029-3

May 1982

Air Force Logistics Management Center

Gunter AFS AL 36114

FORWARD

Last year, we attempted an experiment with LOGCAS 81, namely, to provide the professional logistics analyst and system manager an in-house forum to meet with their peers and share ideas on logistics capability assessment concepts and techniques. We believe the experiment has met with unqualified success. Dialogue exists between attendees, ideas have been traded, and cooperative ventures have been undertaken.

This year, LOGCAS 82 has built on that enthusiasm and interest and was another successful symposium. Again, this success was due to the active participation of the seminar leaders, those who presented papers, and all of the attendees. The Symposium would not have been possible without the advice and support of Major General T. D. Broadwater, Director of Logistics Plans and Programs, DCS/L&E, who convened the Symposium, and to his Deputy, Brigadier General William Bowden, who acted as Chairman. Special thanks are in order for the three speakers: Lieutenant General Richard E. Merkling, Vice Commander, AFLC, who opened the conference with words on the state of logistics analysis in the Air Force; Dr. Edwin B. Stear, Chief Scientist of the Air Force, who drove home the pitfalls and possibilities in the man-machine interface; and Major General Leo Marquez, Commander, Ogden Air Logistics Center, who closed the Symposium with kudos for past work and a challenge for the future.

A great deal of work has been accomplished in logistics capability assessment in the past year. But, this increased insight only serves to make us more aware of what is yet to be accomplished. It is my sincere hope that the ideas learned, the concepts shared, and the contacts made will provide a sound logistics capability assessment program and that with these management tools, we will meet the challenges of the future.

Joseph M. Campbell, Jr.
Lt Col, USAF
Vice Chairman, LOGCAS 82

TABLE OF CONTENTS

Title	Page
Forward	iii
Table of Contents	v-vi
Section I - Introduction	
LOGCAS 82 Announcement and Call for Papers	I-1
Presentation Schedule	I-7
Seminar Schedule	I-14
Biographies of Officials and Presenters	I-15
Section II - Abstracts	
Session A	II-1
Session B	II-15
Section III - Session A Papers	
Dormant Reliability	III-1
The AFLMC Bibliography	III-34
Measuring the Efficiency of Air Force Combat Units	III-49
Tactical Analysis Logistics Information System (TALI)	III-68
Force Capability Assessment System (FOCAS)	III-103
Military Airlift Command Computer System Simulation	III-130
A Prescriptive Model for Resource Allocation at the Intermediate Level Engine Facility	III-145
Balanced Resource Planning: Methodology and Models	III-146
An Approach to Assessing the Combat Value of the European Distribution System (EDS)	III-159
Predictive Engineering Applied to USAF Wheel Logistics	III-187
Using Micro-Computers to Assess Base-Level Munitions Capability	III-202
Overview of MARS Model and its Capabilities	III-216
Life Cycle Cost Techniques	III-226
Section IV - Session B Papers	
An Analysis Model of Sortie Generation at the Flightline	IV-1
A "Real Time" Unit Level WRSK Capability Assessment System	IV-2
Wartine Assessment and Requirements Simulations (WARS) Model	IV-12
Design and Capabilities of Dyna-Tab	IV-26
An Army Methodology for Assessing Logistics Readiness and Sustainability	IV-45
The Impact on Combat Capabilities of Recoverables Awaiting Parts	IV-57
Sensivity Test of Dyna-METRIC	IV-72

A Wartime Push System for Spare Parts IV-87
Modeling Skill Level Effects on Maintenance Capability IV-100
Assessment of the Wholesale and Retail System (AWARES) IV-115
Marine Corps Readiness Evaluations IV-120
Forecasting Wartime Resource Requirements IV-122
Assessing and Improving the Forecasting Attributes of Dyna-METRIC: An F-16 Case Study IV-137
Analytically Modeling the Constrained Repair Problem IV-148

Section V - Additional Papers

Support for Electronic Systems Sold to Foreign Countries V-1
Flight Safety Prediction Technique V-14
Programming for Aircraft Replenishment Spares: Problems and Prospects (SABER PROVIDER-ALPHA) V-30
Planning, Programming, Budgeting and the Air Force V-34
Where Do We Go From Here? V-50

Section VI - Addresses

Opening Address: Lt Gen Richard E. Merkling, Vice Commander, AFLC VI-1
After Dinner Speaker: Dr. Edwin Stear, Chief Scientist of the Air Force VI-13
Closing Remarks: Maj Gen Leo Marquez, Commander, Ogden Air Logistics Center VI-24

Section VII - Participants

Name, Organization, Telephone Number VII-1

USAF LOGISTICS CAPABILITY ASSESSMENT SYMPOSIUM 82

ANNOUNCEMENT AND CALL FOR PAPERS

THE DIRECTORATE OF LOGISTICS PLANS AND PROGRAMS OF THE HQ USAF DEPUTATE OF LOGISTICS AND ENGINEERING ANNOUNCES THE SECOND LOGISTICS CAPABILITY ASSESSMENT SYMPOSIUM WHICH WILL BE HELD AT THE UNITED STATES AIR FORCE ACADEMY, COLORADO, ON 15-19 MARCH 1982.

THE PURPOSE OF THE SYMPOSIUM IS TO PROVIDE A FORUM FOR PROFESSIONAL AIR FORCE ANALYSTS AND PROJECT MANAGERS INVOLVED IN LOGISTICS CAPABILITY ASSESSMENT TO PRESENT PROGRAMS TO THEIR PEERS FOR CRITIQUE AND SHARING OF IDEAS. THE MEETING WILL BE UNCLASSIFIED.

THE THEME OF THE SYMPOSIUM IS "LOGISTICS CAPABILITY ASSESSMENT MODELING - THE NEW MANAGEMENT TECHNIQUE FOR THE 80s." THE CONFERENCE WILL FOCUS ON DETERMINING LOGISTICS CAPABILITY ASSESSMENT MODELS, TECHNIQUES, TOPICS, AND PROJECTS PRESENTLY IN USE, UNDER DEVELOPMENT, AND IN THE PLANNING STAGE.

MEMBERS OF THE LOGISTICS ASSESSMENT COMMUNITY AND OTHER INTERESTED PARTIES ARE URGED TO RETURN THE ACCOMPANYING REQUEST FOR ATTENDANCE TO INITIATE THE INVITATION PROCESS. PLEASE BE AWARE THAT ATTENDANCE IS LIMITED AND ALL INTERESTED APPLICANTS MAY NOT BE ABLE TO ATTEND.

USAF LOGISTICS CAPABILITY ASSESSMENT SYMPOSIUM 82

SYMPOSIUM SESSIONS

THE PROGRAM FOR LOGCAS 82 WILL INCLUDE VARIOUS ACTIVITIES TO OFFER ATTENDEES A BROAD SPECTRUM OF VIEWS FROM DIFFERENT PERSPECTIVES. THE PROGRAM WILL INCLUDE:

GUEST SPEAKERS - SPEAKERS HAVE YET TO BE DETERMINED BUT WILL BE CHOSEN FROM THE LOGISTICS PLANNING AND ANALYSIS COMMUNITY. LOGCAS 81 SPEAKERS WERE

MAJ GEN MARVIN PATTON

MAJ GEN LEO MARQUEZ

MR. STEVE DREZNER, THE RAND CORP.

GENERAL SESSIONS - PRESENTATION OF PAPERS FROM AMONG, BUT NOT LIMITED TO, THE FOLLOWING TOPICS:

MUNITIONS
SUPPLY
MANPOWER
FUTURE LOOK/LONG-RANGE PLANNING
DEPOT/DPEM
MAINTENANCE
INTERNATIONAL LOGISTICS
TRANSPORTATION
DATA BASES
MATHEMATICAL THEORY AND TECHNIQUES

AGENCIES AND/OR INDIVIDUALS DESIRING TO PRESENT A PAPER MUST PREPARE AN APPLICATION PAPER/BRIEFING PRESENTATION FORM (ATTACHED) AND SEND IT TO THE SYMPOSIUM EXECUTIVE SECRETARY BY 1 DECEMBER 1981.

USAF

LOGISTICS CAPABILITY ASSESSMENT

SYMPOSIUM

82

PRESENTATION TOPICS WILL BE REVIEWED BY THE LOGCAS 82 SELECTION BOARD (SEE "ADDITIONAL INFORMATION" PAGE FOR BOARD COMPOSITION) AND THE SPONSORS OF THE SELECTED PAPERS/BRIEFINGS WILL BE NOTIFIED OF THEIR ACCEPTANCE NOT LATER THAN 15 DECEMBER 1981.

WORKING GROUPS - "AROUND THE TABLE" DISCUSSIONS OF THE PRESENTATIONS AND OTHER TOPICS OF PARTICULAR, SPECIALIZED INTEREST.

SEMINARS - TWO SEMINARS ARE PLANNED, THE SUBJECTS HAVE NOT BEEN FINALIZED. WE REQUEST YOUR RECOMMENDATIONS FOR THE PROPOSED SEMINAR SUBJECTS. SUGGESTED TOPICS ARE:

THE PSYCHOLOGY OF SELLING YOUR PROGRAM

USE OF GRAPHICS TO TELL THE STORY

MODEL VERIFICATION AND VALIDATION

DATA BASE MANAGEMENT

MODELING SUBJECTIVE SITUATIONS

USAF LOGISTICS CAPABILITY ASSESSMENT SYMPOSIUM 82

ADDITIONAL INFORMATION

CONVENER:

MAJ GEN T.D. BROADWATER
DIRECTOR, LOGISTICS PLANS AND PROGRAMS
HQ USAF, DEPUTY CHIEF OF STAFF FOR LOGISTICS AND ENGINEERING
PENTAGON, WASHINGTON, D.C. 20330

CHAIRMAN:

BRIG GEN WILLIAM P. BOWDEN
DEPUTY DIRECTOR, LOGISTICS PLANS AND PROGRAMS
HQ USAF, DEPUTY CHIEF OF STAFF FOR LOGISTICS AND ENGINEERING
PENTAGON, WASHINGTON, D.C. 20330

VICE-CHAIRMAN:

LT COL JOSEPH M. CAMPBELL
LOGISTICS CONCEPTS DIVISION
DIRECTORATE OF LOGISTICS PLANS AND PROGRAMS
PENTAGON, WASHINGTON, D.C. 20330

EXECUTIVE SECRETARY:

MAJ DOUGLAS D. COCHARD
DIRECTORATE OF LOGISTICS ANALYSIS
AIR FORCE LOGISTICS MANAGEMENT CENTER
GUNTER AIR FORCE STATION, ALABAMA 36114

LOGCAS 82 SELECTION BOARD:

DIRECTOR, LOGISTICS PLANS AND PROGRAMS, HQ USAF

COMMANDER, AIR FORCE LOGISTICS MANAGEMENT CENTER

CHIEF, LOGISTICS CONCEPTS DIVISION, HQ USAF

DEPUTY DIRECTOR, LOGISTICS PLANS AND PROGRAMS, HQ USAF

USAF LOGISTICS CAPABILITY ASSESSMENT SYMPOSIUM 82

REQUEST FOR ATTENDANCE

REPLY TO: *LOGCAS 82*
EXECUTIVE SECRETARY
MAJOR DOUGLAS D. COCHARD
AFLMC/LGY
GUNTER AFS AL 36114

REPLY DATE: *NOT LATER THAN 15 JANUARY 1982*

NAME OF REQUESTOR: ______________________________

ADDRESS: ______________________________

PHONE NUMBER (INDICATE COMMERCIAL OR AUTOVON) ______________

ADDITIONAL ATTENDANCE REQUESTS:

NAME	*OFFICE SYMBOL*	*PHONE*

NOTES: 1. *NOTIFICATIONS WILL BE MAILED TO ABOVE ADDRESS.*

2. *MULTIPLE ATTENDANCE REQUESTS FROM THE SAME ORGANIZATION MAY BE SUBMITTED AND WILL BE CONSIDERED, SUBJECT TO THE LIMITED SPACE AVAILABLE.*

USAF CAPABILITY ASSESSMENT SYMPOSIUM 82

PAPER/BRIEFING PRESENTATION APPLICATION FORM

PERSONS OFFERING TO PRESENT PAPERS IN THE GENERAL SESSION MUST SUBMIT THIS APPLICATION, IN TRIPLICATE, TO:

LOGCAS 82
EXECUTIVE SECRETARY
MAJOR DOUGLAS D. COCHARD
LOGISTICS MANAGEMENT CENTER
GUNTER AFS, ALABAMA 36114

REPLY DATE: NOT LATER THAN 1 DECEMBER 1981.

NAME: ______________________________

ADDRESS: ______________________________

____

____

____

PHONE NO. (INDICATE COMMERCIAL/AUTOVON) ______________

TITLE: ______________________________

____

EXPECTED LENGTH OF PRESENTATION (MAX 45 MINUTES) __________

PRESENTATION AID REQUIREMENTS ______________________

____

APPLICANT MUST INCLUDE AN OUTLINE, ALSO IN TRIPLICATE, OF THE PROPOSED PRESENTATION. THE OUTLINE SHOULD BE CLEAR, COMPLETE, DOWN-TO-EARTH DESCRIPTION OF THE PROPOSED PAPER/BRIEFING AND NOT A QUALITATIVE ASSESSMENT OF IT. IT SHOULD NOT EXCEED TWO SINGLE-SPACED PAGES. IN ADDITION, APPLICANT MUST PROVIDE A 100-WORD ABSTRACT SUITABLE FOR PROGRAM DESCRIPTION NOTE: PRESENTATIONS, ABSTRACTS, AND PAPERS MUST BE UNCLASSIFIED. LOGCAS 82 WILL BE RESTRICTED TO UNCLASSIFIED MATERIEL.

USAF
LOGISTICS CAPABILITY ASSESSMENT
SYMPOSIUM
82

AGENDA

MONDAY, 15 MARCH 1982

1130-1215	Initial Registration (Sheraton)
1300-1400	Initial Registration (VOQ)
1345	Bus Departs Sheraton for Fairchild Hall
1400	Bus Departs VOQ for Fairchild Hall
1430	Opening Session - Auditorium H-1
1510	Break
1520	Opening Address - Lt Gen Richard E. Merkling
1600	Break for Picture
1630	Buses Depart Fairchild Hall for VOQ & Sheraton
1745	Bus Departs Sheraton for Officers' Club
1800-2000	Cocktail Party at Officers' Club
2015	Bus Departs Officers' Club for Sheraton

****

TUESDAY, 16 MARCH 1982

(Presentation Session A Meets in Lectinar L- 2)
(Presentation Session B Meets in Lectinar L-10)

0800	Bus Departs Sheraton for Fairchild Hall
0815	Bus Departs VOQ for Fairchild Hall
0830	Paper #1
0915	Break
0925	Paper #2
1030	Break
1040	Paper #3
1140	Break for Lunch
1150	Buses Depart Fairchild Hall for Officers' Club
1205	Lunch
1305	Buses Depart Officers' Club for Fairchild Hall
1320	Paper #4
1405	Break
1415	Paper #5
1500	Break
1515	Seminar #1
1645	Seminar Concludes
1700	Buses Depart for VOQ and Sheraton

****

Dr. Stear also has consulted widely with both private industry and the federal government. He has been a member of the Air Force Scientific Advisory Board, serving on the Guidance and Control and the Weapons Panels, and has served as a special consultant for missile flight testing to the commander, Space and Missile Test Center at Vandenberg Air Force Base, Calif. He has also served as a member of the Air Force Office of Scientific Research's Research Advisory Panel and the National Aeronautics and Space Administration's Aeronautical Advisory Committee.

He is a member of the Institute of Electrical and Electronics Engineers, American Institute of Aeronautics and Astronautics, and other professional associations. He also is a member of several scholastic societies including Eta Kappa Nu, Pi Mu Epsilon, Tau Beta Pi and Sigma Xi.

Dr. Stear has written numerous engineering articles and research papers and served as associate editor for the American Institute of Aeronautics and Astronautics Journal of Aircraft. He also has edited books on Hormonal Control Systems and Non-Linear Estimation and Filtering.

He assumed his current position in October 1979.

-30-

BIOGRAPHY
United States Air Force

SECRETARY OF THE AIR FORCE OFFICE OF PUBLIC AFFAIRS WASHINGTON, D. C. 20330

DR. EDWIN B. STEAR

Dr. Edwin B. Stear is the chief scientist of the U.S. Air Force at Washington, D.C.

[redacted] Dr. Stear graduated from Bradley University in 1954 with a bachelor of science degree in mechanical engineering. Upon graduation he received a Hughes Master of Science Fellowship and attended the University of Southern California where he received a master of science degree in mechanical engineering in 1956. He continued his graduate studies at the University of California, Los Angeles, under a Hughes Staff Doctoral Fellowship, receiving his doctor of philosophy degree in electrical engineering in 1961. Dr. Stear was a post doctoral fellow in the Department of Psychiatry at University of California, Los Angeles, from 1972 to 1974, under sponsorship of the Mental Health Training Program where he studied and did research in analysis of brain waves and their clinical uses.

Dr. Stear began his professional engineering career in 1954 with Hughes Aircraft Company. During this association with Hughes, which lasted until 1959, he was involved in the design of missile auxiliary power units, missile guidance and control, and radar receiver analysis and design for the Falcon air-to-air missiles.

In 1961 Dr. Stear entered the U.S. Air Force serving as a project officer in the Flight Control Laboratory at Wright-Patterson Air Force Base, Ohio. He completed his active duty commitment in 1963. He was then appointed manager of the Control and Communication Laboratory of the Lear Seigler Inc., Research Laboratories.

In 1964 Dr. Stear began a distinguished career as an educator in the California university system, an association which continued until his appointment in September 1979 to the Office of the Chief Scientist of the Air Force. Dr. Stear was an assistant professor and associate professor of engineering at the University of California, Los Angeles, from 1964 to 196[illegible], when he transferred to the University of California at Santa Barbara. In 1972 Dr. Stear was appointed professor of electrical engineering and computer science at the University of California at Santa Barbara and became chairman of the department of electrical engineering and computer science in 1975.

Throughout his academic career Dr. Stear was active in curriculum development as well as teaching at both the undergraduate and graduate levels in the areas of modern estimation and filtering theory (Kalman filters), modern control and communication theory and practice, and communication and control aspects of biological systems. Dr. Stear was also active in the University of California, Los Angeles, short course program which was specifically designed to meet the continuing educational needs of the nation's engineering and scientific community.

(Current as of December 1979)

OVER

PREVIOUS PAGE IS BLANK

E. Effective Dates of Promotions:

Grade	Temporary	Permanent
Second Lieutenant	Jul 19, 1950	Jul 19, 1950
First Lieutenant	Jul 16, 1952	Jul 10. 1953
Captain	Mar 3, 1955	Jul 10. 1957
Major	Jul 15, 1963	Jul 10. 1964
Lieutenant Colonel	Nov 21, 1966	Jul 10, 1971
Colonel	Oct 1, 1969	Oct 1. 1973
Brigadier General	Nov 1, 1973	Jun 26, 1975
Major General	Feb 6, 1976	Feb 8, 1979
Lieutenant General	Sep 18, 1979	

(Date of rank Sept. 18, 1979)

12. July 1968 - November 1971, operations staff officer, later chief, Current Tactical Fighter Systems Branch and deputy chief, Tactical Division, Directorate of General Purpose Airlift Forces, Office of the Deputy Chief of Staff for Research and Development, Headquarters U.S. Air Force, Washington, D.C.

13. November 1971 - February 1973, wing vice commander and later commander. 388th Tactical Fighter Wing, Korat Royal Thai Air Force Base, Thailand.

14. February 1973 - December 1973, chief, Air Section, Operations Division, Detachment 1, 1141st U.S. Air Force Special Activity Squadron, Supreme Headquarters Allied Powers Europe, Belgium.

15. December 1973 - March 1975, deputy chief of staff for Operations, Fourth Allied Tactical Air Force, North Atlantic Treaty Organization, Ramstein Air Base, Germany.

16. March 1975 - July 1977, director of aerospace safety, Headquarters Air Force Inspection and Safety Center, Norton Air Force Base, Calif.

17. July 1977 - May 1978, commander and deputy inspector general for inspection and safety, Headquarters Air Force Inspection and Safety Center, Norton Air Force Base, Calif.

18. June 1978 - September 1979, commander, Sacramento Air Logistics Center, McClellan Air Force Base, Calif.

19. September 1979 - present, vice commander, Headquarters Air Force Logistics Command, Wright-Patterson Air Force Base, Ohio.

D. Decorations and Service Awards:

Distinguished Service Medal
Legion of Merit with one oak leaf cluster
Distinguished Flying Cross with four oak leaf clusters
Air Medal with 16 oak leaf clusters
Joint Service Commendation Medal
Air Force Commendation Medal with one oak leaf cluster
World War II Victory Medal
Army of Occupation Medal
National Defense Service Medal with one bronze service star
Korean Service Medal with three bronze service stars
Vietnam Service Medal with one bronze service star
Air Force Longevity Service Award ribbon with six oak leaf clusters
Small Arms Expert Marksmanship ribbon
Republic of Korea Presidential Unit Citation ribbon
Republic of Vietnam Campaign Medal
United Nations Service Medal

PII Redacted

PERSONAL FACT SHEET - LIEUTENANT GENERAL RICHARD E. MERKLING

A. [redacted]

B. Education

Graduated - Hamilton High School, Los Angeles, 1943; University of California at Los Angeles, bachelor of science degree, 1950; Air Force flying school, 1951; Squadron Officer School, Maxwell Air Force Base, Ala., 1955; Aerospace Test Pilot School, 1958; The George Washington University, Washington, D.C., master of science degree, 1968; Air War College, Maxwell Air Force Base, Ala., 1968.

C. Service

1. January 1944 - November 1945, Army Air Forces enlisted status, active duty, aviation cadet.

2. July 1950 - December 1951, student, pilot training, Walker Air Force Base, N.M.

3. January 1952 - December 1952, fighter pilot (F-84), 49th Fighter-Bomber Group, South Korea.

4. December 1952 - November 1955, fighter-gunnery instructor, 3646th Fighter Training Squadron, Laughlin Air Force Base, Texas.

5. November 1955 - April 1958, experimental flight test officer, Headquarters Air Force Armament Center, Eglin Air Force Base, Fla.

6. April 1958 - November 1958, student, Aerospace Test Pilot School, 6512th School Squadron, Edwards Air Force Base, Calif.

7. December 1958 - November 1959, reconnaissance pilot (RF-101), 45th Tactical Reconnaissance Squadron, Misawa Air Base, Japan.

8. November 1959 - June 1962, flight safety officer, Flight and Missiles Safety Division, Headquarters Fifth Air Force, Fuchu Air Station, Japan.

9. June 1962 - November 1966, project officer and later director, Research and Development Division, 4524th Student Squadron, Fighter Weapons School, Nellis Air Force Base, Nev.

10. November 1966 - June 1967, operations officer and aircraft commander (F-4), 555th Tactical Fighter Squadron, Ubon Royal Thai Air Force Base, Thailand.

11. July 1967 - July 1968, student, Air War College, Maxwell Air Force Base, Ala.

July 1967 he entered the Air War College and was a distinguished graduate in July 1968. During the same period he earned his master's degree from The George Washington University. His next assignment was as chief of the Tactical Fighter Branch in the Office of the Deputy Chief of Staff for Research and Development, Headquarters U.S. Air Force, Washington, D.C.

In November 1971 he returned to Thailand as commander of the 388th Tactical Fighter Wing at Korat Royal Thai Air Force Base and logged an additional 135 combat missions in the F-4. The wing played a major role in stopping the North Vietnamese offensive in April 1972 and in counter-offensive operations which led to the signing of a cease-fire in early 1973.

General Merkling was assigned, in February 1973, to Supreme Headquarters Allied Powers Europe, Belgium, where he was chief of the Air Section, Operations Division. In December 1973 he assumed duties as deputy chief of staff for operations for the Fourth Allied Tactical Air Force, a North Atlantic Treaty Organization command located at Ramstein Air Base, Germany. His assignment in this international headquarters included responsibility for staff supervision and direction of all operational matters pertaining to Fourth Allied Tactical Air Force.

General Merkling became the director of aerospace safety, U.S. Air Force Inspection and Safety Center, Norton Air Force Base, Calif., in March 1975 with worldwide supervisory responsibility for the development and implementation of policies, standards and procedures for Air Force flight, ground, missile, space, explosives and system safety engineering programs. General Merkling assumed command of the Air Force Inspection and Safety Center in July 1977. He served in this capacity until June of 1978 when he was assigned as commander of Sacramento Air Logistics Center, McClellan Air Force Base, Calif. In September 1979 he received his present assignment.

He is a command pilot. His military decorations and awards include the Distinguished Service Medal, Legion of Merit with one oak leaf cluster, Distinguished Flying Cross with four oak leaf clusters. Air Medal with 16 oak leaf clusters, Joint Service Commendation Medal and Air Force Commendation Medal with one oak leaf cluster.

General Merkling was promoted to lieutenant general Sept. 18, 1979, with the same date of rank.

He is married to the former Anne Bowen of Brigham City, Utah. They have four children: John, Vicki, Carol and Mark. His hometown is Los Angeles.

Biography
United States Air Force
Secretary of the Air Force, Office of Public Affairs, Washington, D.C. 20330

LIEUTENANT GENERAL RICHARD E. MERKLING

PII Redacted

Lieutenant General Richard E. Merkling is vice commander, Air Force Logistics Command with headquarters at Wright-Patterson Air Force Base, Ohio.

General Merkling [redacted], and graduated from Hamilton High School, Los Angeles. He has a bachelor of science degree in mechanical engineering from the University of California and a master of science degree in international affairs from The George Washington University, Washington, D.C. He completed Squadron Officer School in 1955 and Air War College in 1968. Both schools are located at Maxwell Air Force Base, Ala.

As a member of the Army Air Forces Reserve he was called to active duty in January 1944 in an enlisted status. He later became an aviation cadet. At the end of World War II his pilot training was terminated and he was discharged in November 1945. He then entered the University of California at Los Angeles, graduating in June 1950. A month later he received his commission as a second lieutenant in the U.S. Air Force as a distinguished Air Force Reserve Officers' Training Corps graduate.

General Merkling immediately re-entered flying training. By December 1951 he had completed basic and advanced pilot training and fighter combat crew training. From January to December 1952, he served in South Korea flying more than 100 combat missions in F-84s with the 49th Fighter-Bomber Group.

He returned to the United States and was assigned as a fighter-gunnery instructor and assistant group operations officer with the 3646th Fighter Training Squadron at Laughlin Air Force Base, Texas. He attended Squadron Officer School and in November 1955 was assigned as a flight test pilot at Eglin Air Force Base, Fla., where he flew F-86s, F-94s and F-100s. He was also project manager for development of the M-61 aerial cannon and the F-104, F-101 and F-105 armament systems. In April 1958 he entered the Aerospace Test Pilot School at Edwards Air Force Base, Calif., and flew a wide variety of experimental aircraft.

In December 1958 General Merkling went to Japan where he was an RF-101 reconnaissance pilot at Misawa Air Base. He later was a member of the Fifth Air Force Tactical Evaluation Team, flying F-100s and RF-101s. He returned to the United States in June 1962 to serve as an operations officer and later as director of the Research and Development Division of the Fighter Weapons School at Nellis Air Force Base, Nev.

In November 1966 he returned to the Far East as operations officer for the 555th Tactical Fighter Squadron (the famed "Triple Nickel") of the 8th Tactical Fighter Wing at Ubon Royal Thai Air Force Base, Thailand. He flew 100 combat missions over North Vietnam in the F-4. In

(Current as of January 1980)

OVER

SEMINAR AND DISCUSSION GROUPS

Auditorium H-1

1515-1645 - Seminar #1, Tuesday, 16 March 1982

The Programming, Planning, Budgeting Cycle
as it Relates to Logistics Capability Assessment

Chairman - Major William Campbell, HQ USAF/PRPFS

1510-1645 - Seminar #2, Thursday, 18 March 1982

Small Computer Innovations for the Logistics Manager

Chairman - 1Lt Karen Daniels, AFLMC/LGY

Participants:

Lt Col Walter Atkins

Maj Doug Cochard, AFLMC/LGY

Capt Bob James

Dr. Warren Langley, R&D Associates,
Colorado Springs, Colorado

0830-0945 - Discussion Group, Friday, 19 March 1982

Where Do We Go From Here? Part II

Chairman - Lt Col Joe Campbell, HQ USAF/LEXY

USAF LOGISTICS CAPABILITY ASSESSMENT SYMPOSIUM 82

1040-1140	8	An AFLC Wartime Spares "Push" System: Lt Col Robert S. Tripp, OO-ALC/MMM-1 40 Minutes
1320-1425	9	Modeling Skill Level Effects on Maintenance Capability: Capt Joseph P. Racher, Jr., AF Logistics Management Center 45 Minutes

****

THURSDAY, 18 MARCH 1982

0830-0935	10	Assessment of Wholesale and Retail System (AWARES): Dr. Jim Bigelow, The Rand Corp. 45 Minutes
0945-1030	11	Marine Corp Aviation Readiness Evaluation: Dr. W. H. Marlow, the George Washington University 30 Minutes
1040-1130	12	Forecasting Wartime Resource Requirements: Col Donald C. Tetmeyer or Mr. Frank A. Maher, AF Human Resource Laboratory 35 Minutes
1310-1355	13	Assessing and Improving the Forecasting Attributes of Dyna-Metric -- An F-16 Case Study: Maj Jon R. Thomas, AF Element, The Rand Corp. 30 Minutes
1410-1455	14	Analytically Modeling the Constrained Repair Problem: Gordon Crawford, The Rand Corp. 30 Minutes

USAF LOGISTICS CAPABILITY ASSESSMENT SYMPOSIUM 82

PRESENTATION SESSION B

LECTINAR L-10

CHAIRMAN - LT COL JOSEPH M. CAMPBELL

TUESDAY, 16 MARCH 1982

Time	Paper No.	Title/Presenter/Paper Length
0830-0915	1	An Analysis Model of Sortie Generation at the Flight Line: Dr. Mort Berman, The Rand Corp. 30 Minutes
0925-1030	2	Real Time Unit Level WRSK Capabilty Assessment System: Lt Col Ronald W. Clarke, HQ TAC/LGYT 45 Minutes
1040-1140	3	Wartime Assessment and Requirements System (WARS): Ms Diann Lawson AFLC/LORA 40 Minutes
1320-1405	4	The Mathematical Foundations of Dyna-Tab: Manuel J. Carrillo, The Rand Corp. 30 Minutes
1415-1500	5	TLR/S - An Army Methodology for Assessing Logistics Readiness and Sustainability: James A. Cohick, DALO-LEP (New Cumberland Army Depot) 30 Minutes

****

WEDNESDAY, 17 MARCH 1982

Time	Paper No.	Title/Presenter/Paper Length
0830-0935	6	The Impact on Combat Capability of Recoverables Awaiting Parts - AWP - The #1 Spares Problem: Maj William D. Arnold, HQ TAC/LGSW 45 Minutes
0945-1030	7	Sensitivity Testing of Dyna-Metric: Maj Wayne Graybeal, Air Command and Staff College 30 Minutes

USAF LOGISTICS CAPABILITY ASSESSMENT SYMPOSIUM 82

1040-1140	8	Balanced Resource Planning: Donald L. Zimmerman, Synergy, Inc. 40 Minutes
1320-1425	9	Assessing the Combat Value of the European Distribution System (EDS): Dr. Mort Berman, The Rand Corp. 45 Minutes

****

THURSDAY, 18 MARCH 1982

0830-0935	10	Modeling Ground Launched Cruise Missile Availability: Cpt Gary W. Hoenshell, AFTEC/LG4 45 Minutes
0945-1030	11	Predictive Engineering as it Applies to USAF Aircraft Wheel Logistics: Mr. Robert Howard, OO-ALC/MMIRC 30 Minutes
1040-1130	12	Using Microcomputers to Assess Base-Level Munitions Capability: Cpt Mark Greenly, AFLMC/LGM 35 Minutes
1310-1355	13	DLA Materiel Readiness Support (MARS) Model: Cpt William R. Frazier, DLA/LOO 30 Minutes
1410-1455	14	Life Cycle Cost Models: Ms Freda W. Kurtz, AFALD/XRSC 30 Minutes

****

USAF LOGISTICS CAPABILITY ASSESSMENT SYMPOSIUM 82

PRESENTATION SESSION A

LECTINAR L-2

CHAIRMAN - MAJ DOUGLAS D. COCHARD

TUESDAY, 16 MARCH 1982

Time	Paper No.	Title/Presenter/Paper Length
0830-0915	1	Dormant Reliability - A New Modeling Challenge: K. C. Schwarz, AFTEC/LGY 30 Minutes
0925-1030	2	The AFLMC Logistics Capability and Readiness Assessment, Bibliography: Dr. W. H. Marlow, the George Washington University 45 Minutes
1040-1140	3	Data Envelopment Analysis and Air Force Capability Assessment: Maj Terry Clark, AFIT, University of Texas 40 Minutes
1320-1405	4	Tactical Analysis of Logistics Information (TALI) System: Mr. John Greene, HQ TAC/LGXS 30 Minutes
1415-1500	5	Force Capability Assessment System (FOCAS): Maj James D. Blanchard, HQ TACOPS/DOCR 30 Minutes

****

WEDNESDAY, 17 MARCH 1982

Time	Paper No.	Title/Presenter/Paper Length
0830-0935	6	Supply and Maintenance Considerations in Modeling Intertheater Military Airlift Operations: Maj C. L. Bragaw, HQ MAC/XPSR 45 Minutes
0945-1030	7	A Prescriptive Model for Resource Allocation at the Intermediate Level Engine Facility: Cpt Edward Connolly HQ MAC/LGXA 30 Minutes

USAF

LOGISTICS CAPABILITY ASSESSMENT

SYMPOSIUM

82

FRIDAY, 19 MARCH 1982

0800	Bus Departs Sheraton for Fairchild Hall
0815	Bus Departs VOQ for Fairchild Hall
0830	Discussion Session - Auditorium H-1 - Lt Col Joe Campbell
0945	Break
1000	Closing Address - Maj Gen Leo Marquez
1035	Closing Remarks - Brig Gen William Bowden
1050	Symposium Ends
1100	Buses Depart Fairchild Hall for VOQ and Sheraton
1210	Buses Depart VOQ and Sheraton for Peterson Field/ Colorado Springs Municipal Airport

****

USAF LOGISTICS CAPABILITY ASSESSMENT SYMPOSIUM 82

WEDNESDAY, 17 MARCH 1982

0800	Bus Departs Sheraton for Fairchild Hall
0815	Bus Departs VOQ for Fairchild Hall
0830	Paper #6
0935	Break
0945	Paper #7
1030	Break
1040	Paper #8
1140	Break for Lunch
1150	Buses Depart Fairchild Hall for Officers' Club
1205	Lunch
1305	Buses Depart Officers' Club for Fairchild Hall
1320	Paper #9
1425	Break for Tour
	Backup Time for Picture
1440	Buses Depart Fairchild Hall for Sheraton, VOQ, and Tour
1640	Tour Ends, Buses Drop Off Passengers at VOQ and Sheraton

****

THURSDAY, 18 MARCH 1982

0800	Bus Departs Sheraton for Fairchild Hall
0815	Bus Departs VOQ for Fairchild Hall
0830	Paper #10
0935	Break
0945	Paper #11
1030	Break
1040	Paper #12
1130	Break for Lunch
1140	Buses Depart Fairchild Hall for Officers' Club
1155	Lunch
1255	Buses Depart Officers' Club for Fairchild Hall
1310	Paper #13
1355	Break
1410	Paper #14
1455	Break
1510	Seminar #2 - Auditorium H-1
1645	Seminar Concludes
1700	Buses Depart Fairchild Hall for VOQ and Sheraton
1815	Bus Departs Sheraton for Officers' Club
1830	Pre-Dinner Open Bar at Officer's Club
1900	Dinner
2000	After Dinner Speaker - Dr. Edwin Stear
2130	Bus Departs Officers' Club for Sheraton

****

Biography

United States Air Force

Secretary of the Air Force, Office of Public Affairs, Washington, D.C. 20330

MAJOR GENERAL LEO MARQUEZ

PII Redacted

Major General Leo Marquez is commander of the Ogden Air Logistics Center, Hill Air Force Base, Utah.

General Marquez [redacted] and graduated from Belen (N.M.) High School in 1949. He received a bachelor of science degree in zoology from New Mexico State University, Las Cruces, in 1954, and a master of science degree in business administration from The George Washington University, Washington, D.C., in 1967. The general completed Air Command and Staff College, Maxwell Air Force Base, Ala., in 1967 and attended the advanced management program for executives, Carnegie-Mellon University, Pittsburgh, in 1976. In 1978 he was named a distinguished alumnus from New Mexico State University.

He was awarded a commission through the Air Force Reserve Officers' Training Corps program upon graduation from New Mexico University and entered active duty as a second lieutenant in the U.S. Air Force in November 1954.

After completing pilot training in January 1956 at Greenville Air Force Base, Miss., and the basic instructor course at Craig Air Force Base, Ala., he returned to Greenville as a flight instructor in T-33s. While there he also completed the instructor pilot instrument school at Moody Air Force Base, Ga.

In September 1958 he began the interceptor pilot course at Moody Air Force Base, flying F-86D's. Upon graduation in May 1959, he was assigned to the 525th Fighter-Interceptor Squadron, Bitburg Air Base, Germany, where he flew F-102s until January 1962.

He returned to the United States to attend the aircraft maintenance officer course at Chanute Air Force Base, Ill. Following completion in mid-1962, he was assigned to the 325th Fighter-Interceptor Wing at McChord Air Force Base, Wash., as a maintenance officer. In 1964 he became commander of the 325th Organizational Maintenance Squadron at McChord.

General Marquez entered the Air Command and Staff College in August 1966. Following graduation as a distinguished graduate in August 1967, he was assigned to the 3rd Tactical Fighter Wing, Bien Hoa Air Base, Republic of Vietnam, as maintenance control officer.

In August 1968 General Marquez was selected for exchange duty with the Canadian Forces in Ottawa, Canada, and served as system manager for the CF-100, CF-101, CF-104, T-33 and BOMARC missile. In August 1970 he transferred to Headquarters Tactical Air Command, Langley Air Force Base, Va., as the F-111 logistics project officer in the Directorate of

(Current as of September 1981) OVER

Maintenance Engineering, Office of the Deputy Chief of Staff, Logistics. In 1972 he was reassigned within the directorate as chief, Fighter Reconnaissance Branch.

General Marquez was chief of the F-111 System Management Division in the Directorate of Materiel Management at the Sacramento Air Logistics Center, McClellan Air Force Base, Calif., from June 1973 to July 1975. He then was assigned as director of materiel management at Warner Robins Air Logistics Center, Robins Air Force Base, Ga., from July 1975 to August 1977.

The general transferred to Headquarters U.S. Air Force, Washington, D.C., in September 1977 as deputy director of maintenance engineering and supply, Office of the Deputy Chief of Staff, Systems and Logistics. He was assigned as deputy director of logistics plans, programs and transportation, Office of the Deputy Chief of Staff, Logistics and Engineering, in April 1978. The Office of the Deputy Chief of Staff, Systems and Logistics, became the Office of the Deputy Chief of Staff, Logistics and Engineering, in July 1978.

In June 1979 he became deputy chief of staff for plans and programs at Headquarters Air Force Logistics Command, Wright-Patterson Air Force Base, Ohio. He assumed his present command in July 1981.

His military decorations and awards include the Legion of Merit with one oak leaf cluster, Bronze Star Medal, Meritorious Service Medal and Air Force Commendation Medal with one oak leaf cluster. He was selected as Air Force Logistics Command Systems Manager of the year in 1974. In 1977 he was the recipient of the Air Force Association's Executive Management Award.

He was promoted to major general July 1, 1981, with date of rank Sept. 1, 1977.

General Marquez and his wife, Stella, have five children: Paula, Patricia, Frank, Leo and Diana.

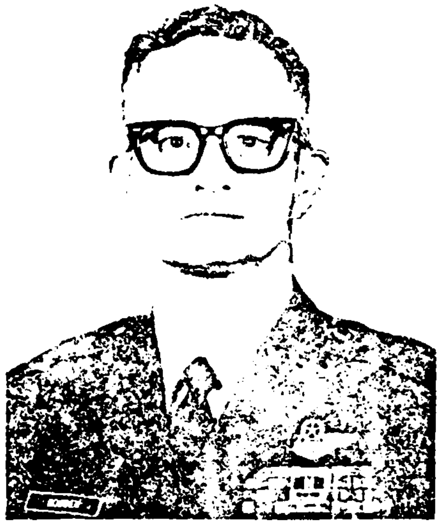
Biography

United States Air Force

Secretary of the Air Force, Office of Public Affairs, Washington, D.C. 20330

BRIGADIER GENERAL WILLIAM P. BOWDEN

PII Redacted



Brigadier General William P. Bowden is the deputy director for logistics plans and programs, Office of the Deputy Chief of Staff for Logistics and Engineering, Headquarters U.S. Air Force, Washington, D.C.

General Bowden [redacted], where he graduated from high school in 1950. He graduated from the University of Arkansas in 1954 with a bachelor of science degree. He has a master's degree in business administration from The George Washington University and a second in political science from Auburn (Ala.) University. His professional military education includes Air Command and Staff College and the Air War College, both schools are located at Maxwell Air Force Base, Ala.

He received his commission through the Reserve Officers' Training Corps program at the University of Arkansas and entered active duty in September 1954. He reported to Harlingen Air Force Base, Texas, for navigator training in October 1954, completed the course in October 1955, and immediately moved to Mather Air Force Base, Calif., for navigator-bombardier training. Upon graduation in March 1956, he was assigned to the 6th Bombardment Wing, Walker Air Force Base, N.M., as a B-36 bombardier until 1958. The wing then converted to B-52s and he remained there through July 1959.

His next assignment was at Eglin Air Force Base, Fla., with the 4135th Strategic Wing as a standardization instructor navigator-bombardier. At that time the wing was involved in B-52 testing of the AGM-28 air to surface missile and the ADM-20 decoy missile. In 1962 General Bowden transferred to the Strategic Air Command Project Office at the Air Proving Ground Center, Eglin Air Force Base to work air to surface missile testing, B-52 avionics development and conventional munitions test programs.

From July 1964 to June 1965, he attended the Air Command and Staff College and concurrently obtained a master of science degree in business administration from The George Washington University cooperative education program on Maxwell Air Force Base.

Following Air Command and Staff College he was assigned to Headquarters Strategic Air Command, Offutt Air Force Base, Neb., in avionics requirements. His programs included B-52 offensive avionics, KC-135 system modifications and RC-135 reconnaissance modifications.

In September 1969 he joined the B-52 Arc Light program at U-Tapao Royal Thai Naval Airfield, Thailand, as an operations officer. He flew 44 combat missions.

(Current as of May 1981)

OVER

General Bowden reported to Air Force headquarters in September 1970, Office of the Deputy Chief of Staff for Plans and Operations, Directorate for Force Development. He was a manager for fighter war readiness materiel support logistics planning for conventional munitions. The programs he was involved with included the Maverick and laser guided bombs.

He completed the Air War College, class of 1972-73, as a distinguished graduate. He also obtained a master's degree in political science from Auburn University's Maxwell Air Force Base Campus. That led to a tour of duty as a faculty instructor and chief of the Curriculum Planning Division at the Air War College. He participated in implementing the change of the Air War College program of study from national-international affairs to one more oriented to air power applications.

From March 1976 to August 1978, the general was the KC-135 system manager at Oklahoma City Air Logistics Center, Tinker Air Force Base, Okla., and later became the combined system manager for B-52s, A-7s and KC-135s. He was then assigned as director of materiel management. In this assignment General Bowden managed a number of engine improvement programs and several aircraft life extensions and modernization programs. One of these programs was the initiation of the air-launched cruise missile modification.

General Bowden was assigned as assistant deputy chief of staff, logistics operations, Headquarters Air Force Logistics Command, Wright-Patterson Air Force Base, Ohio, in April 1980 and assumed his present duties in April 1981.

The general is a master navigator and has 4,500 flying hours. His military decorations and awards include the Legion of Merit, Meritorious Service Medal, Air Medal with one oak leaf cluster and Air Force Commendation Medal. In September 1980 he was awarded the Air Force Association's Thomas P. Gerrity Award for Logistics Management.

He was promoted to brigadier general Jan. 23, 1981, with date of rank Jan. 18, 1981.

General Bowden is married to the former Isobel Anderson of Nashville, Tenn. They have two children: Andy and Marjorie. His hometown is Swifton, Ark.

BIOGRAPHICAL SKETCH

of

LT COL JOSEPH M. CAMPBELL

Lt Col Joseph Campbell received his BS in Mechanical Engineering at Louisiana State University in 1961 and entered the Air Force that same year. After completing pilot training, the next several years were spent flying fighter interceptors at Perrin AFB, TX; Truax Field, WI; Clark AB, RP and SEA; and again at Perrin. In 1971, he went to the Air Force Institute of Technology at Wright-Patterson AFB, OH where he graduated with an MS in Aero-Mechanical Engineering.

Lt Col Campbell then began his logistics career with three years at the Sacramento Air Materiel Area (now Air Logistics Center) first in Service Engineering and finally as Chief of the Logistics Research Group. After a second tour in SEA and two years with the 89th Military Airlift Wing, he worked for two years in the Directorate of Operations and Plans at Headquarters, USAF. The last three years have been in the Logistics Concepts Division in the Directorate of Logistics Plans and Programs at the Pentagon where he is the Deputy Division Chief. Lt Col Campbell has worked extensively in the logistics analysis and computer modeling fields and is the program manager responsible for orchestration of Air Force Logistics Capability Assessment improvement efforts. He founded and developed the Air Force's Logistics Capability Assessment Symposium.

Lt Col Campbell is a Colonel Selectee and is slated to become the Director or Plans and Programs at the San Antonio Air Logistics Center this summer.

BIOGRAPHICAL SKETCH

MAJOR DOUGLAS D. COCHARD
LOGCAS 82 EXECUTIVE SECRETARY

Major Douglas D. Cochard is Chief, Management Science Division, Air Force Logistics Management Center, Gunter AFS, Alabama. He earned his B.S. in Administrative Science from Bowling Green State University, Bowling Green, Ohio in 1967. He holds an M.S. in Systems management from the Air Force Institute of Technology and an M.S. in Operations Research from Florida Institute of Technology. He has worked primarily in Systems Command and at the Air Force Technical Applications Center. Prior to his current assignment, he received a Ph.D. in Operations Research from the University of Texas in Austin.

BIOGRAPHICAL SKETCH

MAJOR WILLIAM D. ARNOLD

Major Arnold is Chief of the Assessment and Development Branch in the Supply Directorate, Headquarters Tactical Air Command. He earned his B.S. in accounting at Michigan State University and his M.S. in Logistics Management at the Air Force Institute of Technology. He is Supply Officer, having had base level assignments at Seymour Johnson AFB and Minot AFB. Additionally, in SAC he was a member of the 15th AF Inspector General Team. His overseas assignments have been as an advisor first at Benhoa, Vietnam and later in Tehran, Iran with the Air Force Advisory Team. During the past two years he has been assigned to the Weapons Systems Support Division, collecting and analyzing data on effectiveness of supply support for TAC weapons systems.

BIOGRAPHICAL SKETCH

LT COL WALTER J. ATKINS, JR.

Lt Col Walter J. Atkins, Jr. is currently the Deputy Head of the Department of Electronic Engineering and Tenure Associate Professor at the Air Force Academy. He received a B.S. in Electronic Engineering from Howard University in 1965, an M.S. in E.E. from the University of Illinois in 1971, and a Ph.D. in E.E. from the University of Illinois in 1977. He worked in communications from 1965 through 1972 and has been at the AFA since 1972, except for the time spent getting his Ph.D. Lt Col Atkins is a Senior Member of IEEE.

MORTON B. BERMAN

Education

Dr. Berman received his B.S. in Aeronautical Engineering from New York University in 1957, his M.S. in Industrial Engineering from Texas Technological University in 1965, and his Ph.D. in Policy Analysis from the Rand Graduate Institute in 1974.

Professional Experience

Dr. Berman joined The Rand Corporation in 1968. He is a Senior Scientist in the Information Sciences Department and Project Leader in the Resource Management Program of Project AIR FORCE.

Dr. Berman has led a series of studies concerned with investigating the ability of various support resources to sustain wartime flying operations. He has also led a project devoted to examining resource decisionmaking within Air Force Flying Operations.

His early work at Rand was in the area of developing large-scale analytical and simulation models. He participated in developing a MAC Flight Scheduling Model, the FAST-VAL Weapon Effects System and a pattern recognition model for vehicle sensor devices.

JAMES H. BIGELOW

James H. Bigelow received his B.S. with honors in mathematics and engineering from the University of California at Berkeley in 1975, and his Ph.D. in operations research from Stanford University in 1970. At Stanford he combined studies in his major field with substantial study in physiology, which became his minor subject. He came to Rand first as a graduate-student consultant and has been full time since 1969.

He has been involved in a wide range of project types at Rand. More recently, Dr. Bigelow has joined a project to assess the peacetime material readiness and wartime sustainability of U.S. Air Forces. His primary responsibilities are to formulate and implement models for making two sorts of calculations: first, to calculate support requirements of the operating forces, given a description of the scenario(s) to be supported; and second, to calculate the operating scenario(s) that the operating forces would be capable of flying, given a description of the resources available for their support.

PII Redacted

BIOGRAPHICAL SKETCH

NAME: Major James R. Blanchard, [redacted]

DATE OF RANK: 14 Aug 78

CURRENT ASSIGNMENT: Readiness Operations Staff Officer, Hq Tactical Air Command

[redacted]

FAMILY: Wife - Trina

CIVILIAN/MILITARY EDUCATION: Bachelor of Arts, Louisiana State University in New Orleans, 1967; Undergraduate Navigator Training, 1968; Combat Crew Training, A-26, Mar 1969; Instructor Navigator Course, Mar 1970; Squadron Officer School, Oct 1973; Weapon System Officer Course, F-4, May 1974.

MILITARY BACKGROUND/RATING: Commissioned from Officer Training School, Nov 1967. Undergraduate Navigator Training Feb 1968 - Nov 1968. Combat Crew Training for A-26, Dec 1968 - Mar 1969. A-26 and C-123 Navigator, 609 and 603 Special Operations Squadrons, Nakhon Phanon Royal Thai Air Base, Thailand, Mar 1969 - Dec 1969. Instructor Navigator, Undergraduate Navigator Training School, Mather AFB, CA., Jan 1970 - Jan 1974. Weapon System Officer (F-4C), 67 TFS, Kadena AB, Okinawa, Japan, Jul 1974 - Jun 1975; 18 TFW Flight Examiner, attached to 44 TFS and 25 TFS (F-4D) Kadena AB, Jun 1975 - Dec 1976. Air Operations Staff Officer, Readiness Initiatives Group, HQ Tactical Air Command, Jan 1977 - Jan 1980. F-4D/E refresher course Jan - Feb 1980. 8 TFW (F-4D) Wing Scheduling Officer and Chief of Current Operations, Kunsan AB, Republic of Korea, Apr 1980 - Apr 1981. Assigned Readiness Operations Staff Officer, Readiness Initiatives Division, HQ Tactical Air Command May 1981.

BIOGRAPHICAL SKETCH

MAJOR CHARLES L. BRAGAW

Major Charles L. Bragaw is Deputy Chief of the Operations Research Division, Directorate of Studies and Analysis, Deputy Chief of Staff, Plans, HQ Military Airlift Command. Since his assignment to HQ MAC in 1978, he has assisted in the application of simulation techniques to military airlift operations questions. He has previously served on the mathematical sciences faculty at the Air Force Academy and as a modeler-analyst at the Air Force Technical Applications Center. Major Bragaw is a graduate of Colorado State University and earned a Master's Degree in mathematics from Duke University.

BIOGRAPHICAL SKETCH

Manuel J. Carrillo, Ph.D.

Obtained doctorate in Operations Research from UCLA School of Engineering in 1975. Assistant Professor of Management Science at the University of Texas at Dallas for the period 1975-1978, after which joined Rand. Previous research includes mathematical programming and queueing theory. Co-author of the capability assessment model Dyna-METRIC and of publications of some policy studies where model was used.

BIOGRAPHICAL SKETCH

Major Charles T. Clark, USAF

Present Position: Ph.D. Program, Department of General Business, BEB 600, University of Texas at Austin, Austin, Texas 78712

[redacted] PII Redacted

Education: BA, Mathematics, Pan American University, 1963; MS, Systems Analysis, Air Force Institute of Technology (AFIT), 1972; Squadron Officers School, 1973; Air Command and Staff College, 1975.

Military Background: Instructor and Phase Chief, Aircraft Systems, Chanute AFB, Illinois, 1967-70; Student, AFIT, 1970-72; Analyst and Branch Chief, Headquarters Military Airlift Command, 1972-76; Chief, Field Maintenance Division, Incirlik Common Denfense Installation-NATO, Turkey, 1976; Chief, Organizational Maintenance Division, Incirlik - NATO, 1977; Project Manager, AFLMC, 1977-78; Chief, Programs Division, Air Force Logistics Management Center, 1979-81.

Special Project Assignments: Malfunction Detection Analysis and Recording/ Ground Processing System (MADAR/GPS), C-5 aircraft; Contingency Operation, Mobility Planning and Execution System (COMPES); Comprehensive Project Management System for the AFLMC.

R. WARREN LANGLEY

Dr. R. Warren Langley is a Research Scientist with the Colorado Springs Office of R & D Associates. His current work includes productivity measures in DoD health care systems; micro computer applications for enhancing military health care management; military command, control and communications modeling; and interactive systems for energy resource forecasts and analysis. He recently implemented a national network using micro computers to link members of the RDA staff and several consultants who are working in common technical areas.

Prior to joining RDA, he was Director of the Office of Energy Market Analysis and Forecasting in the Department of Energy, and during his fifteen years in the Air Force worked on a myriad of problems in operations research applications as well as serving as a member of the faculty of the U.S. Air Force Academy. He is active in the Operations Research Society of America and the Institute of Management Sciences, having chaired their Joint National Meeting in Colorado Springs in 1980. He currently teaches Management Control and Forecasting as an Adjunct Associate Professor in the College of Business at the University of Colorado in Colorado Springs.

He is married and has two children who are competitors for time on his Apple II computer.

FREDA W. KURTZ

Freda W. Kurtz is an operations research analyst performing cost estimating work in the Air Force Acquisition Logistics Division (AFALD/XRSC), located at Wright-Patterson Air Force Base, Ohio. Prior to her present assignment, she was an operations research analyst in the Air Force Avionics Laboratory. She has held other assignments as a financial specialist and a statistician at Wright-Patterson Air Force Base and at Andrews Air Force Base. In addition to her Air Force position, she is an instructor in economics at Sinclair Community College in Dayton, Ohio.

During the past year, she completed the Air War College Seminar Program with a grade of excellent. She is also a recent recipient of the Certified Professional Logistician Certificate.

In June 1979, she was the top winner of the 1979 Professional Employee of the Year Award competition of the Dayton Metropolitan Area given by the Dayton Chapter of International Personnel Management Association and Dayton Area Chamber of Commerce. Approximately 26,000 federal employees were in the competition area. She also received a certificate from the House of Representatives of the State of Ohio, in recognition of her selection as 1979 Professional Employee of the Year.

In June 1978, she was the top winner of the 1978 Equal Employment Opportunity Award competition of the Dayton Metropolitan Area given by the Dayton Chapter of International Personnel Management Association and Dayton Area Chamber of Commerce.

She has a B.S. degree from the Northeast Missouri State University and a M.A. degree from the University of Kentucky and is currently completing the requirements for a doctorate. She was valedictorian of both her high school and college graduating classes. She has recently taken classes at Ohio State University, the University of Michigan, the University of Colorado, and Wright State University.

She served two years as National Treasurer of Federally Employed Women, the organization which represents the approximately 770,000 women employed by the federal government. She is currently on the National Executive Committee and the National Board of that organization.

BIOGRAPHICAL SKETCH

CAPT ROBERT L. JAMES

Capt Robert L. James is now an Instructor of Mathematics at the Air Force Academy. He received a B.A. in Mathematics from the University of Texas at Austin in 1970, an M.S. in Operations Research from the University of Texas in 1971, and a Ph.D. in Operations Research, also from the University of Texas, in 1981. His assignments have included HQ USAF from 1971 to 1975, Air Force Data Systems Design Center from 1975 to 1979, and a student at AFIT from 1979 to 1981.

BIOGRAPHY

Mr Robert L. Howard currently serves as an Engineering Specialist for predictive engineering in support of Aerospace Vehicle Alighting Gear Systems and for Airborne and Ground Photo/Reconnaissance Systems in the Directorate of Material Management at Ogden ALC, Hill Air Force Base, Utah. Previously he was assigned to the Directorate of Maintenance and has also received extensive experience in private industry. He has a Bachelors Degree in Engineering and a Masters Degree in Applied Statistics.

Biography

Captain Gary W. Hoenshell

Captain Gary W. Hoenshell is currently assigned as a weapon systems analyst at the Air Force Test and Evaluation Center (AFTEC), Logistics Studies and Analysis Division, located in Kirtland AFB NM.

Captain Hoenshell enlisted in the Air Force in 1971 and worked as a crewmember on the Titan II missile weapon system before being accepted for the Airman Education and Commissioning Program. He earned his Bachelor of Science degree in Industrial Engineering from Mississippi State University in 1975. This was followed by a Master of Science degree in Industrial Engineering from the same University in 1976. He spent four years at Wright-Patterson AFB OH working in the Engineering Directorate of the Aeronautical Systems Division (ASD). During this time he served as the propulsion performance engineer for the cruise missile engine. He conducted many engine performance studies using engine computer simulation programs supplied by the manufacturers.

Captain Hoenshell's present duties at AFTEC require him to analyze and evaluate logistics concerns of the Ground Launched Cruise Missile (GLCM) program during its operational testing. Most of the analysis is accomplished with computer simulation models which represent detail flows of the weapon system's operation.

ATCH 1

BIOGRAPHY

Mark D. Greenly
Captain, USAF

Capt Greenly received his Bachelor of Science Degree from Michigan State University in 1974. He was commissioned through ROTC and entered the Munitions Maintenance Officer Career Field (AFSC 4054). He has been assigned to Mountain Home AFB, Idaho, and to Spangdahlem AB, Germany. His positions have included Assistant OIC, Weapons Loading Section and OIC, Munitions Maintenance and Storage Branch.

Capt Greenly received his Master of Science Degree in Logistics Management from AFIT's School of Systems and Logistics at Wright-Patterson AFB, Ohio.

Presently, Capt Greenly is assigned to the Air Force Logistics Management Center, Gunter AFS, Alabama, as a Project Manager for logistics studies. His current projects include the use of the Logistics Composite Model (LCOM) as a munitions capability assessment tool, and the development of a classroom management simulation exercise for the Munitions Officer Course at Lowry Technical Training Center.

BIOGRAPHICAL SKETCH

MR. JOHN H. GREEN

Mr. John H. Green is currently assigned to HQ TAC, Directorate of Logistics Plans, Langley AFB, Virginia, as a Logistic Management Specialist. His current duties include assignment as the project manager for the Tactical Analysis Logistics Information System and its inclusion into the Contingency Operation Mobility Planning and Execution System (COMPES). He began his career in 1960 when he joined the USAF and after 20 years of military service retired in 1980. His military career included assignments in Supply, Maintenance, and Logistics management. Mr. Green worked as a store manager for Pantry Pride, Inc. until September 1981 when he moved to his present position.

BIOGRAPHY

PII Redacted Major Wayne T. Graybeal [redacted] and attended schools there. He enlisted in the United States Air Force in 1962, and was commissioned in 1969. His educational background includes a B.S. in Mathematics (University of Oklahoma - 1969), an M.A. in Mathematics (University of Arizona - 1970), and a PhD in Computer Science (Texas A&M University - 1979). His publications include the textbook Simulation: Principles and Methods (Winthrop Publishers, Inc., 1980) and "The Design of Calibration Experiments for Synthetic Jobs" (The Computer Journal, Vol 24, No 2, 1981). Both of these works were coauthored with Udo W. Pooch. His most recent assignment was as an Associate Professor of Mathematics, United States Air Force Academy. He has accepted appointment as a Tenure Associate Professor of Mathematics, United States Air Force Academy, and will assume that position upon graduation from the Air Command and Staff College in June, 1982.

CAPTAIN WILLIAM R. FRAZIER, JR., USAF

Captain Frazier graduated from Southern Methodist University in 1970 with a B. S. degree in Mathematics. He earned his commission there through the AFROTC Program. From July 1970 to April 1974 he served in four assignments as an Air Intelligence Officer. From May 1974 to May 1978 he served in three assignments as an Electronics Systems Maintenance Officer. From June 1978 to December 1979 he was in the Operations Research Program in the School of Engineering at AFIT. In January 1980 he assumed his current position as an Operations Research Officer in the Operations Research and Economic Analysis Office at the Headquarters, Defense Logistics Agency.

BIOGRAPHICAL SKETCH

1LT KAREN M. DANIELS

1Lt Karen M. Daniels is a Computer Systems Development Officer for the Logistics Analysis Directorate of the Air Force Logistics Management Center, located at Gunter AFS, Alabama. She received a B.A. in Mathematics with a minor in Computer Science from Cornell University, Ithaca, New York.

GORDON B. CRAWFORD

Education

Dr. Crawford received his B.S. and M.S. degrees in mathematics and statistics from the University of Oregon in 1958 and 1959. He held General Electric and IBM Fellowships at Princeton University and received an M.A. in mathematics and a Ph.D. in probability theory there in 1960 and 1962.

Professional Experience

Dr. Crawford worked in the Operations Analysis office at Headquarters PACAF before coming to Rand in 1977. At PACAF he developed the stock leveling procedure used at the PACAF Centralized Intermediate Logistic System and began research on generalizing steady state inventory models to the dynamic processes appropriate for Air Force WRM calculations.

At Rand he continued the research on dynamic inventory models and is currently a project leader in the Resource Management Program of Project AIR FORCE.

BIOGRAPHICAL SKETCH

Edward Connolly

Capt Edward Connolly graduated from the USAF Academy in June 1977. He served as an aircraft maintenance officer in MAC from Jan 78-Jun 80. He attended Air Force Institute of Technology (AFIT) from Jun 80 through Jun 81 and received a Master of Science in Acquisition Logistics Management. Capt Connolly is currently assigned to HQ MAC as a Logistics Systems Analyst.

BIOGRAPHICAL SKETCH

Mr. James A. Cohick is the Chief, Planning and Evaluation Team, in the US Army Logistics Evaluation Agency. He has a masters degree in mathematics from the University of Illinois. Mr. Cohick has been involved in modeling and simulation of Army logistics functions for the past 14 years. During this time he has written several articles on the subject, two of which appeared in the Army Logistician Magazine.

BIOGRAPHICAL SKETCH

Lieutenant Colonel Ronald W. Clarke

Lt Colonel Clarke is Chief, Tactical Resources Analysis Division, Deputy Chief of Staff, Logistics, Headquarters Tactical Air Command. He earned his BS in Mathematics from the University of North Carolina at Chapel Hill in 1963 and his MS in Industrial Engineering with a major in Operations Research from the University of Alabama in 1972. The first six years of his Air Force career was in the Air Weather Service. This was followed by tours in the Air Force System Command and the Air Force Test and Evaluation Center. His current responsibilities include managing a group of analysts engaged in logistics capability assessment applications for the Tactical Air Forces.

DIANN LAWSON

BIOGRAPHY

Ms Lawson is the Chief of the Reserach and Analysis Branch in the Directorate of Material Requirements and Financial Resource Management, Deputy Chief of Staff/Logistics Operations at HQ Air Force Logistics Command.

She received a BS in Mathematics with a minor in Computer Science from Wright State University, Dayton, Ohio. She attained her M.S. Degree in Logistics Management in June 1978 from the Air Force Institute of Technology (AFIT). There, she won the honor of Distinguished Graduate and became a member of the Sigma Iota Episolon National Honorary Society. Ms Lawson has also earned the designation of Certified Professional Logistician from the Society of Logistics Engineers.

Ms Lawson plans and directs analysis concerned with relating materiel policies and procedures, as well as funding resources (actual and planned), to weapon system support. Her past work has involved the application of the Mod-METRIC model to the F15/F16 weapon systems, research and recommending alternative approaches to repair level analysis modeling, and to wholesale supply computational systems. Ms Lawson has received several awards during her career in the Air Force and has participated on various JLC and DOD study groups on inventory stockage policies.

Captain James R. Lowell enlisted in the United States Air Force in June 1960. In 13 years enlisted service as an avionics technician he maintained radio, inertial navigation, navigation radar and doppler radar systems on bomber, cargo, fighter, and drone aircraft. He also performed duties as maintenance debriefer quality control inspector, and avionic maintenance analyst. Sponsored by the Air Force Institute of Technology (AFIT) Airman Education and Commissioning Program, he earned the degree Bachelor of Science in Industrial Engineering from New Mexico State University and was commissioned a Second Lieutenant in November 1973. After commissioning, he served as a manpower management officer at HQ TAC, Langley AFB VA and OLAA, 4400 Management Engineering Squadron, Wright-Patterson AFB Ohio. Sponsored by AFIT, Captain Lowell earned the degree Master of Science in Engineering from Arizona State University in December 1979. He is presently assigned to the Air Force Test and Evaluation Center (AFTEC) as a weapon systems analyst. His awards include the Meritorious Service Medal, two Commendation Medals, and the Tactical Air Command, Management Engineering Professional Excellence award for 1977. Captain Lowell is a senior member of the American Institute of Industrial Engineers.

BIOGRAPHICAL SKETCH

Dr. W. H. Marlow

Dr. W. H. Marlow is Professor of Operations Research; Director, Institute for Management Science and Engineering; and Principal Investigator, Program in Logistics; all at The George Washington University. His doctorate is in mathematics from the University of Iowa.

The Institute for Management Science and Engineering is a multidisciplinary environment for graduate teaching and research under diversified sources of external support. Previous efforts in logistics research have concerned allowance lists and load lists for the Polaris Weapons System, transportation scheduling for contingency planning, the Navy's 3-M program, and manpower management for the Marine Corps. Major current efforts consist of research on "cost of ownership" for the Navy and "readiness assessments" for the Marine Corps. As an individual researcher, Dr. Marlow has been especially active in the latter program.

Dr. Marlow's publications include: (1976) (Editor) Modern Trends in Logistics Research, MIT Press; (1978) Mathematics for Operations Research, Wiley; (1979) (Co-author) Survey of approaches to Readiness, Naval Research Logistics Quarterly; and (1981) (Co-author) The AFLMC Bibliography.

BIOGRAPHY

JOSEPH P. RACHER, JR.
Captain, USAF

Capt Racher received his Bachelor of Science Degree from the United States Air Force Academy in 1976. Upon receiving his commission, he entered the Aircraft Maintenance Officer Career Field (40XX). After technical training at Chanute AFB, Illinois, Capt Racher was assigned to an F-4 Wing in Germany. While in Germany, Capt Racher's positions included Branch OIC in AMS, Flightline Maintenance Officer in OMS, and Management Support Division Chief on the DCM Staff.

Capt Racher received his Master's Degree in Logistics Management from AFIT's School of Systems and Logistics at Wright-Patterson AFB, Ohio.

Presently Capt Racher is assigned to the Air Force Logistics Management Center at Gunter AFS, Alabama, as a Project Manager for logistics studies. His current project involves developing a workcenter management handbook for the aircraft maintenance community. Future research areas Capt Racher is interested in are analysis of base level maintenance capability and identification of methods for improving base level maintenance capability.

Biography

K. C. Schwarz

Captain K. C. Schwarz is currently assigned to the Air Force Test and Evaluation Center (AFTEC) Logistics Division, Kirtland AFB NM, as a reliability analyst. He is presently involved in the reliability analysis of several major weapon systems including the B-1B, F-16E, and the Ground Launched Cruise Missile. Prior to the assignment at AFTEC he flew C-9's at Scott AFB IL. He holds a Bachelor of Science degree in Engineering Sciences from the USAF Academy and a Master of Science degree in Engineering/Engineering Management from Stanford University.

BIOGRAPHICAL SKETCH

COLONEL WILLIAM T. STALLINGS

Colonel William T. Stallings is the Director of Studies and Analysis, Deputy Chief of Staff, Plans, HQ Military Airlift Command. His involvement in Airlift Systems Analysis began during his previous assignment to the Office of the Assistant Chief of Staff, Studies and Analysis, HQ United States Air Force, where he successively served as Chief of the Mobility Division and Deputy Director for Theater Force Analysis. He is a command pilot, having flown 5600 hours in a variety of transport aircraft while stationed in New Jersey, Germany, Thailand and Iran. He also served 5 years on the mathematical sciences faculty of the Air Force Academy. Colonel Stallings is a graduate of the University of the South and has earned advanced degrees in mathematics from the University of Texas (M.A.) and Texas Tech University (Ph.D.).

BIOGRAPHICAL SKETCH

TETMEYER, DONALD C., COLONEL, USAF

PII Redacted [redacted]

Colonel Tetmeyer is Chief of the Logistics and Technical Training Division of the Air Force Human Resources Laboratory located at Wright-Patterson Air Force Base, Ohio. Previous assignments have included tours in the Office of the Assistant Secretary of Defense for Manpower, Reserve Affairs and Logistics, and as Chief of the Modeling and Analysis Branch in the Air Force Systems Commands Aeronautical Systems Division. He holds a Ph.D. in Systems Research from Ohio State University.

MAJOR JON R. THOMAS

Education

Major Thomas received a B.S. degree in Mathematics at Kent State University in 1965 and a M.S. degree in Systems Analysis at the Air Force Institute of Technology in 1972.

Professional Experience

Major Thomas received a commission from Officer Training School in 1966 and worked as a Communications Officer until he entered the AFIT School of Engineering in 1970. Upon graduation he was assigned to Studies and Analysis at the Air Staff where he predominately worked Close Air Support and AGM-65 studies. From there he was assigned to the Directorate of Plans, Hq AFLC, where he worked numerous studies in the area of readiness measurement and capability assessment including participation on the WARS definition work group. In July 1981, he became the Logistics Research Fellow at Rand.

BIOGRAPHICAL SKETCH

LT COL ROBERT S. TRIPP

Lt Col Robert S. Tripp is currently assigned to the Ogden Air Logistics Center as the Chief, Readiness Initiatives Group. The mission of this Group is to develop information systems and models which show how logistics support alternatives impact weapons systems readiness. This information is used by AFLCs System Managers to influence support decisions. Previous assignments include tours with HQ AFLC in Plans and Programs, AFIT as a faculty member in the Department of Systems Management, and Electronics Systems Division of Air Force Systems Command.

February 23, 1982

DONALD L. ZIMMERMAN

Donald L. Zimmerman is a principal with Synergy, Inc., a Washington, D.C. consulting firm specializing in public policy economics. As a senior economist with over ten years of experience, Mr. Zimmerman has directed numerous analytical projects and is responsible for specific aspects of overall firm management. Much of his work at Synergy involves the use of data, computerized models, and other analytical techniques to evaluate policy alternatives. He has experience in designing and managing the development of information systems which support senior decision-makers in the defense and energy areas.

Mr. Zimmerman has consulted for numerous federal agencies including the Department of Defense, Department of Energy, Department of Interior, and Environmental Protection Agency. During 1980, Mr. Zimmerman was on a one-year leave of absence to serve as a senior economist in the Executive Office of the President.

During the last five years, Mr. Zimmerman has focused primarily on analytical problems related to Air Force logistics policy. Past research for the Air Staff includes the modeling of reparable spares and readiness relationships and operational considerations in defnining spares requirements. Current projects are oriented toward readiness and sustainability resources, especially munitions, and their analysis in the context of a balanced POM.

Mr. Zimmerman has Bachelor's and Master's degrees in economics from Illinois State University and was a doctoral fellow at Virginia Polytechnic Institute and State University. He has published research in national journals and recently has been a senior lecturer in economic statistics at the University of Maryland.

SECTION II

Abstracts of Presentations Delivered During LOGCAS 82

Abstracts are arranged in order shown on the Presentation Schedule, pages I-10 - I-13. Arrangement is Session A, then Session B.

ABSTRACT

Title of Paper: Dormant Reliability: A New Modeling Challenge

Presenter and Organization: Capt K. C. Schwarz
Air Force Test and Evaluation Center
Logistics Studies & Analysis Division
Kirtland AFB NM 87117

Reliability of military systems such as munitions after long periods of storage has been a major concern throughout history. As weapon systems become more complex and their expected response times become shorter, the need to understand and project dormant reliability becomes more critical.

AFTEC is currently involved in the test and evaluation of munition systems which will spend the majority of their life in the dormant state. This paper describes the engineering efforts involved in quantifying dormant reliability. It will begin by describing early efforts and then lay the groundwork for future models.

Serial 72373
24 November 1981

The AFLMC Logistics Capability and Readiness Assessment Bibliography

W. H. Marlow
Program in Logistics
The George Washington University

Abstract

A bibliography of about 750 published and unpublished works was recently completed by the Program in Logistics. A four-way taxonomy -- type of readiness, methodological approach, military service, military unit -- is applied and keywords are used to address further specifics of the references. Results from analyses conducted concurrently with assembly of the biobliography — on the taxonomy, on the works assembled, on proposed standards, and final recommendations — are presented.

ABSTRACT

Measuring the Efficiency of Air Force Combat Units

by

Major Charles T. Clark
Ph.D. Program, University of Texas at Austin

A. Charnes, W.W. Cooper, A. Bessent, and W. Bessent (all of the University f Texas at Austin), together with E. Rhodes (State University of New York) have eveloped and tested a new method called DEA (Data Envelopment Analysis) for easuring and evaluating the efficiency of not-for-profit enterprises. The echnique applies to both military and civilian problems which invlove multiple-utput as well as multiple-input situations for each of a variety of managerial nits. This paper examines the criterion of efficiency, briefly describes the EA model and software, and suggests areas of further study.

WARS: A Progress Update

Abstract

This briefing will provide an update on the development of the model discussed by Victor J. Presutti, Jr. at LOGCAS 81. The subject of his briefing was "A Non-Stationary Model that Relate Aircraft Availability to Recoverable Item Assets." This model is called the Wartime Assessment and Requirements Simulation (WARS) Model and will be used to develop WRM requirements for aircraft recoverable items. The model is stockastic, dynamic, multi-echelon, and multi-indenture. It was developed to accommodate the transition from peace to war and provide assessments by squadron based on aircraft available.

The briefing for LOGCAS 82 will review the background of the model development, and its application, compare the model to our current computational system, delineate the overall concept of the model, discuss the output concept of the model, demonstrate its outputs, and describe the current status.

"REAL TIME" UNIT LEVEL WRSK CAPABILITY ASSESSMENT SYSTEM

ABSTRACT

The Dyna-METRIC model is a logistics capability assessment tool that can be applied to a variety of analysis problems related to spare parts and automatic test equipment resources. In applying Dyna-METRIC to build tables which relate increments of on-hand stock to increments of sorties accomplished or available aircraft, it became desirable to more fully automate the table production process. This lead to the development of a derivative of Dyna-METRIC which was developed by the Rand Corproation and named Dyna-TAB. The presentation first covers the background and details of the specific application for which Dyna-TAB was designed. Also, discussion will include the interfacing of Dyna-TAB with the Combat Supplies Management System (CSMS) to produce a "real time" unit level WRSK capability assessment system.

Attachment 2

An Analytic Model of Sortie Generation at the Flight Line

R. Hillestad and B. Leverich

Sortie generation is limited by many factors including the availability of operational level maintenance personnel, the need for ground equipment, the availability of spares for broken components, and the schedule of takeoff times. This paper describes a simple linear programming model which schedules aircraft and flight line resources to maximize sorties for a day (subject to an optional upper limit). It considers pre-flight and post-flight tasks, resource requirements and the possible occurrence of missed takeoffs due to component failures and shortages. Since input data includes the allowable takeoff times, either massed aircraft generation or continuous generation can be investigated. The model can be used as a post-processor for other capability assessment models to provide a detailed description of sortie capability.

LIFE CYCLE COST MODELS

FREDA W. KURTZ
Air Force Acquisition Logistics Division
Wright-Patterson AFB, Ohio

Cost estimates for weapon systems are important as a source of information on which decisions are based. Although many different cost models have been developed and used for specific purposes, cost models are basically of two different types - parametrics cost estimating models and engineering or build-up cost estimating models.

Each basic type of cost model - parametric or engineering - has specific advantages and certain disadvantages. Each type is appropriate for use under certain conditions.

Cost estimates for major weapon systems are needed before design details and operational concepts are completely formulated. Parametric cost models are appropriate for use during the early phases of the life cycle of a weapon system. Parametric cost estimates are developed through the use of cost models based on CERs (Cost Estimating Relationships) and factors developed from the historical cost data of similar systems already in the operating inventory.

As soon as a weapon system passes from the early design and development phases of the life cycle into the phase during which detailed information becomes available, it becomes possible for the cost analyst to use engineering type estimating models. Engineering type or build-up cost models require detailed input information. Detailed production data become available when the prototypes of the aircraft or other weapon systems have been built. Reliability and other logistics type data start to become available as soon as the early test exercises are begun. At this time engineering or build-up type cost estimating models may be used for the development of cost estimates.

Engineering or build-up estimates require input data down to the lowest level of unit to be repaired. Parametric cost models, on the other hand, usually provide information only down to the major subsystem level. Engineering models require information on specific maintenance labor manhour requirements and labor rates. They also require input information concerning the specific spare parts projections to be required by the subsystem being studied. The input data for engineering estimates should be refined by the use of feedback data generated from the test and operation of the system.

DLA Materiel Readiness Support (MARS) Model

The Materiel Readiness Support (MARS) model is an analytical tool for measuring support of weapon systems and military organizations directly related to the nation's readiness posture. MARS will identify consumable items that support weapon systems and specific military units and then measure supply support for those items. The model will also project future performance and provide a cost/support relationship.

USING MICROCOMPUTERS TO ASSESS BASE-LEVEL MUNITIONS CAPABILITY

Capt Mark D. Greenly

ABSTRACT

This paper addresses the uses of microcomputers at base-level to assess munitions capabilities. It discusses types of questions which this capability may be able to address. It presents several prototype programs for capability assessment of munitions storage area and flightline aircraft loading operations. Relevant issues relating to hardware and software are presented and discussed in light of the Air Force environment. The paper concludes that microcomputers can be used as a capability assessment tool in this area, but that many unanswered questions remain. These questions offer directions for future efforts to validate microcomputers in the capability assessment arena.

ABSTRACT

PREDICTIVE ENGINEERING
AS IT APPLIES TO
USAF AIRCRAFT WHEEL LOGISTICS

Methods of predictive logistics analysis are described utilizing past history, current trends, logistics personnel expertise, hardware testing and mathematical models. The analyses are utilized to support logistics decisions to maintain maximum Air Force mission capability.

Modeling Ground Launched Cruise Missile Availability

Presenter: Capt Gary Hoenshell
HQ AFTEC/LG4
Kirtland AFB NM 87117

Abstract

The ground launched cruise missile (GLCM) weapon system is another concurrent development program quickly approaching its initial operational capability (IOC) date of December 83. AFTEC will evaluate availability of the system during the combined development/operational test and evaluation. This will be accomplished through a simulation model of the GLCM weapon system and its operational environment which includes aspects such as reliability and maintainability characteristics, the users maintenance and operations concepts, support equipment, test equipment, manpower, facilities, and training. To produce an accurate model, the analyst requires a great deal of detailed information early in the acquisition cycle, typically before the hardware is completed or system design is frozen. The detailed information should come from program documentation such as the Statement of Operational Need and Preliminary System Operation Concept. However, the detailed system description required to build a computer simulation model has typically not been included until very late in the development/test phase of the acquisition process. In developing the model, the analyst is often forced to make many assumptions. The contractor, program office, and user are finally forced to provide a detailed system description in response to the modeler's needs.

ASSESSING THE COMBAT VALUE OF THE EUROPEAN DISTRIBUTION SYSTEM (EDS)

Improvements in USAF combat capability might be obtained by a variety of alternative changes to logistics sytems. Such alternatives include improvements to repair capability, increases in stockage levels, improved distribution techniques or investments to protect against enemy damage to logistics. There is a need for techniques that can simultaneously examine alternatives across logistics functions. This paper provides a case study for discussing appropriate capability assessment techniques. The study examines alternatives for improving the USAF combat capability in the European theater during wartime. The results of this study formed the basis for USAF plans on a European Distribution System (EDS).

11/30/81

ABSTRACT

Balanced Resource Planning:
Methodology and Models

by:

Mr. Donald L. Zimmerman
Col. Richard Olson
Lt. Col. William Smiley
Dr. Terrence R. Colvin

During the 83-87 POM development cycle, the Air Force was successful in presenting a resource expenditure plan directly related to operational capability that balanced multiple individual logistics programs. The resulting outputs have received widespread attention from the Air Staff, Navy, OSD, OMB, and the Congress.

This paper describes the analytical approach taken to address this issue, the specific methodologies employed, and the outputs. Current modeling efforts in support of the 84-88 POM and new directions being explored are described. The relationships between the Logistics Capability Measurement System (LCMS) Overview Model's results for reparable spares based on DØ41 data and AFLC/LOR budget estimates, and results for munitions, POL, and other resource areas developed by other analysts are discussed. Particular attention is given to the macro modeling of air-to-ground munitions and sustainability issues.

A Prescriptive Model for Resource Allocation at the Intermediate Level Engine Facility

Inability to support spare engine requirements has a critical impact on this nation's ability to meet its worldwide commitments during a crisis. This study examined those factors that significantly affect the intermediate level Propulsion Branch's ability to provide a steady supply of spare engines. Through simulation modelling and analysis, four factors were identified as driving the Base Repair Cycle time: spare parts, repair equipment, manpower, and experience level. A decision support system was developed which enables users to assess the influence on repair cycle time of additional funding levels in specific factor areas.

ABSTRACT

SUPPLY AND MAINTENANCE CONSIDERATIONS IN MODELING INTERTHEATER MILITARY AIRLIFT OPERATIONS

The Military Airlift Command has developed M-14, a GASP-based simulation model of its wartime, intertheater airlift system. The model tracks aircraft, air crews, and base resources, producing station and system performance statistics; it plans mission itineraries and simulates their execution. This model was developed to address questions about airlift operations that were beyond the scope of MAC's earlier notionalized models. Modeling of scheduled and unscheduled maintenance and activity against supply assets, as well as sensitivity of system performance parameters to these aspects of system operation, will be discussed. Some study results will also be presented.

FORCE CAPABILITY ASSESSMENT SYSTEM (FOCAS)

FOCAS is an automated system developed by a tri-command working group (TAC, PACAF, and USAFE) to determine the potential combat capability of Tactical units by measuring their ability to produce sorties in a wartime surge environment. Data concerning 14 elements, such as aircraft and munitions, is input to an array of algorithms which produce a potential number of sorties for each element. The lowest is the unit limiting factor. Multiple input changes may be made, followed by rapid recalculations, allowing a user to game various options concerning resource allocation, use rates, etc., in an attempt to optimize sortie output.

Tactical Analysis Logistics

Information System

(TALI)

The Tactical Analysis of Logistics Information (TALI) System represents the most advanced computer program available to Air Force Logistics planners for the management of war consumables. Its consolidated worldwide data base is derived from standard automated asset reports. By applying specific commodity expenditure/consumption factors, it is possible to determine actual support required for "what if" scenarios to satisfy wartime contingencies and peacetime operations. Analysis of products generated allows logistics planners to identify and resolve potential problems that will affect the supportability of tactical forces. TALI will become a standard Air Force system under the Contingency Operation/Mobility Planning and Execution System (COMPES).

ABSTRACT

The Mathematical Foundations of Dyna-TAB

Dyna-TAB is a table look-up system for on-site capability assessment of a flying unit for given parts' reliability, repair factors, and starting stock. Three mathematical concepts used in Dyna-TAB are discussed. First, the separate Non-Mission Capable (NMC) time profile of individual parts is used to estimate the total NMC when a computer is not available. Second, computational effort is minimized in estimating capability by considering few part categories, each covering a group of individual parts, instead of individual parts data. Finally, a flying program adjustment model deals with shortfall of the goal due to parts unavailabilities.

BRIEFING ABSTRACT

TITLE: TLR/S - AN ARMY METHODOLOGY FOR ASSESSING LOGISTICS READINESS AND SUSTAINABILITY

BRIEFER: Mr. James A. Cohick

ORGANIZATION: The US Army Logistics Evaluation Agency

ABSTRACT: A continuing need has existed for Army logisticians to assess and articulate the effect on primary weapon system combat readiness and battle sustainability resulting from shortages in support equipment and degraded capabilities of combat service support units.

This need is part of an overall effort in the Army to "balance the forces" to assure that a proper mix of combat to combat support units is maintained so that "for want of a nail" the battle is not lost.

The USALEA Total Logistics Readiness and Sustainability (TLR/S) assessment is an important contribution to this effort. It uses output from many other Army sources to arrive at an assessment of the impact of logistics capabilities on the major combat functions of "shoot, move and communicate." It breaks this assessment down by combat arms branch (i.e., infantry, armor, artillery, etc.) so that it is meaningful to the Major Army Commanders and Combat Arms Planners who will be most affected by the results.

This briefing describes, in a general and unclassified way, how the assessment is developed and provides an example of the analysis and output.

Abstract

The Impact on Combat Capability of Recoverables Awaiting Parts

AWP The #1 Spares Problem

This paper addresses the impact on TAC combat capability of recoverable spares that are unserviceable due to a lack of repair parts; the end item awaiting parts is considered AWP. Overall, ten TAC fighter aircraft squadrons are Not Mission Capable (NMC) due to lack of parts for all reasons (AWP plus all other reasons required parts are not available). Fifteen percent of these aircraft are grounded because the spare parts needed are, in turn, AWP. Thus, 1.5 fighter squadrons are Not Mission Capable due to AWP; consequently, 598 fewer sorties could be flown in the first seven days of war. This makes AWP the #1 spares problem.

How big is the problem? Generally, almost 3,000 items become AWP during a month, and each AWP item waits an average of 37 days for repair parts. AWP time is not accounted for in the stockage computation models and, therefore, we have over 100,000 asset days in the pipeline which are not included in the requirements computation. The turn-over of items is large (different items in the AWP pipeline each month), but only a small number of items show up repeatedly.

How bad is it? NMC requirements are increasing because full base stocks are tied up in AWP, and this increase is evident across the TAC aircraft fleet. Some of the hard-core problem items show continued AWP problems and resulting NMC aircraft requirements.

Who runs the show? Our review of the problem shows a large percentage of component repair parts are in turn reparable items. In fact, looking at the hard-core problem repair parts, 88% are recoverable items repaired at depot level. Four Air Force depots account for 76% of the unfilled base stock levels for these items. Between 60% and 90% of the demands for items managed by these depots were for items with base stock levels, but no stock was on hand. Split management of repair parts and end items may cause problems in coordinating actions, however, we find that 19 of the 20 top problem items are managed at the same ALC.

Conclusion. AWP is a serious problem, and the "driver" appears to be reparable subassemblies managed by AFLC. In many cases, the subassembly and end item are managed by the same ALC.

Sensitivity Testing of Dyna-METRIC

Abstract

The use of models to simulate the operation of real-world systems has become widespread in the past few years. Since the models are separated from the real systems by multiple levels of abstraction, the fidelity of the abstraction must be tested. Testing usually involves validation actions (testing the agreement between the real system and the system model) and verification actions (testing the agreement between the system model and the computer code). This report documents a study conducted to test the sensitivity of various Dyna-METRIC output variables to changes in input parameters. A framework for future studies was established, and the techniques were illustrated by their application to a test case. This study is a portion of an extensive verification effort underway at the Air Force Logistics Management Center.

Three output variables were of primary interest in this study: the expected Non-Mission Capables due to Supply (NMCS) both in the full cannibalization and no cannibalization modes, and the expected sorties flown. The study proceeded in three distinct phases. First, the effect on NMCS of changes in the flying hour program was examined. Second, the effect on sorties of changes in the maximum sortie turn rate was studied. In both cases, the implementation of the analytic expressions were verified, and a factorial experiment conducted. The final phase assessed the effect on NMCS of particular LRUs, with an eye toward reducing the size of the input data set. A heuristic approach was taken to calculate the expected end stock for each LRU. A decision was then made whether to retain or eliminate the LRU based upon the magnitude of the expected end stock. This technique shows considerable promise.

ABSTRACT

AN AFLC WARTIME SPARES "PUSH" SYSTEM

During Exercise Potent Punch 81/Ulchi Focus Lens (Fall 81), the Director of Materiel Management at Ogden Air Logistics Center (ALC), Utah was tasked by HQ AFLC to test an "ALC wartime push system for aircraft spares." Ogden ALC used its Dyna-Metric capability assessment model to forecast sortie limiting items from D day to D+60. Using this technique, 56 critical items were identified as potential sortie limiting items. However, because of the "Push" or Planned Depot Resupply System, the goal of having no more than 15% of the Aircraft Not Fully Mission Capable was attained through D+60. Although there were some limitations in the first time effort, the addition of an Ogden ALC interface with the Combat Supplies Management System and Worldwide Military Command and Control System will enhance the system significantly and lend it to expansion to the other four ALC's.

MODELING SKILL LEVEL EFFECTS ON MAINTENANCE CAPABILITY

Capt Joseph P. Racher, Jr.

ABSTRACT

An inherent part of aircraft maintenance capability is the ability of the maintenance technicians to perform quality and timely maintenance actions. This paper provides a systems analysis review of the maintenance workcenter to obtain insight into how the varying ability levels in the workforce affect maintenance capability. At the heart of this analysis is the modeling of the decision process used to assign the proper skill level technician to the correct jobs. Just as important, is the modeling of the decision processes used to conduct on-the-job training. A simulation model must capture these decision processes in order to assess how skill level impacts maintenance capability.

Attachment 1

AWARES (Assessment of Wholesale And Retail System)

R. Hillestad and J. Bigelow

Assessing the impact of the Air Force and Navy wholesale logistics systems (wholesale stocks, depot level component repair, and transportation) on aircraft availability and capability in wartime scenarios is important for addressing funding, organization, and capacity issues. Since the wholesale system supports the retail system the assessment must be performed while considering the resources available at the squadron and base level. This paper describes a model designed to perform this assessment while considering the interaction between the wholesale and retail systems. The model is composed of a scenario generator, a depot maximum workload generator, a minimum requirements estimator, and a shop capacity model. Illustrations of time phased depot workload and implications for the wholesale system will be provided.

ABSTRACT

MARINE AVIATION READINESS EVALUATIONS. Dr. Barzily, Zeev, Program in Logistics, George Washington Univ., Washington, DC 20052. Dr. Marlow, W. H., Dept. of Operations Research, George Washington Univ., Washington, DC 20052. Turner, Jr. Lt Col Samuel D., Headquarters, USMC, Code POR, Washington, DC 20380.

The Marine Corps Combat Readiness Evaluation System (MCCRES) determines the readiness of all Marine aviation squadrons. Alternative measures of performance, based on MCCRES data, are presented which isolate fundamental aspects of performance and which identify trends in readiness.

FORECASTING WARTIME RESOURCE REQUIREMENTS

Col Donald C. Tetmeyer
Frank A. Maher
Logistics and Technical Training Division
Air Force Human Resources Laboratory

ABSTRACT

As an expedient to forecasting wartime resource requirements such as maintenance demands, a straightline extrapolation from peacetime demands to wartime based on the ratio of flying hours is often made. There are two difficulties with this. First, as recent research sponsored by the Human Resources Laboratory has shown, there are many causitive factors other than flying time that significantly influence demands. Second, as is expected but not much researched, the pattern of wartime usage differs considerably from that of peacetime, making predictions based on peacetime usage dubious. The experience of the Israeli Air Force in the "Yom Kippur" war with respect to battle damaged aircraft is instructive in this regard. Additional research on these questions is being undertaken by the Human Resources Laboratory in support of Hq AFLC and others, divided at developing the tools needed by the decisionmakers to evaluate and plan Base level combat capabilities.

ABSTRACT

Assessing and Improving the Forecasting Attributes of Dyna-METRIC An F-16 Case Study

This study is designed to improve our understanding of the merits and limitations of using Dyna-METRIC for the F-16 System Manager's Quarterly Projection Assessment and will identify areas for further research. Although the study is not a full scale validation of Dyna-METRIC, it will provide insights into how a reasonable verification program for inventory models can be conducted.

The presentation shows how input data problems can be isolated from model problems. Furthermore, examples will be given which illustrate how tests comparing Dyna-METRIC to actual data can be made for pipeline quantities, base backorders and Not Fully Mission Capable rates.

ABSTRACT

Analytically Modeling the Constrained Repair Problem

Virtually all analytic models of the repair process for reparable LRUs assume sufficient repair capacity (equipment and personnel) to insure that the time to repair an LRU is independent of past demand history. This assumption, always dubious and often important, is flagrantly violated by weapon systems that rely on a limited number of Automated Test Equipment stands.

This presentation outlines an analytic approach and numerical solution to this constrained repair problem characterized by: 1) a time varying arrival rate, 2) different parts served by the same server, and 3) the number of servers changes in time. The solution is applicable to certain departures from the common first-come-first-served assumption.

Section III

Session A Papers

Moderator: Major Douglas D. Cochard
Chief, Management Sciences Division
Directorate of Logistics Analysis
Air Force Logistics Management Center
Gunter AFS AL

Papers are in order of presentation during LOGCAS 82. Refer to pages I-10 and 11 for presentation order. Not all presentations have papers associated with them.

AIR FORCE TEST & EVALUATION CENTER

DORMANT RELIABILITY

BRIEFER: CAPT K C SCHWARZ

LOGISTICS STUDIES & ANALYSIS

WHAT IS DORMANT RELIABILITY?

RELIABILITY CAN BE CONSIDERED TO BE THE PROBABILITY THAT AN ITEM WILL REMAIN FAILURE FREE OVER A SPECIFIED PERIOD OF TIME UNDER SPECIFIED CONDITIONS (OR BE IN A FAILURE FREE STATE AFTER A SPECIFIED PERIOD OF TIME). THE SAME DEFINITION APPLIES TO DORMANT RELIABILITY EXCEPT THAT WE RESTRICT OUR AREA OF INTEREST TO NON-OPERATING OR DORMANT STATES. DORMANT RELIABILITY IS A SUBSET OF THE MORE GENERAL RELIABILITY TERM.

WHAT IS DORMANT RELIABILITY?

RELIABILITY	THE PROBABILITY THAT AN ITEM WILL REMAIN FAILURE FREE FOR A SPECIFIED PERIOD OF TIME UNDER SPECIFIED CONDITIONS
DORMANT RELIABILITY	THE PROBABILITY THAT AN ITEM WILL REMAIN FAILURE FREE FOR A SPECIFIED PERIOD OF TIME UNDER NON-OPERATING CONDITIONS; I.E., ALERT, STORAGE, ETC.

NOT A NEW PROBLEM

THE RELIABILITY OF MILITARY SYSTEMS AFTER LONG PERIODS OF DORMANCY IS NOT A NEW PROBLEM. IT HAS BEEN A CONCERN THROUGHOUT MILITARY HISTORY. IN EARLY TIMES, SPOILAGE OF FOOD AND GUNPOWDER WAS A MAJOR CONCERN. WHEN AIRCRAFT ARE TEMPORARILY GROUNDED, CARE IS TAKEN TO MITIGATE THE EFFECTS OF NONUSE (E.G., FLAT TIRES, FLUID DRAIN, ETC.).

THE SUCCESS OF MANY MILITARY OPERATIONS DEPENDS ON A SYSTEM REMOVED FROM STORAGE PERFORMING ITS INTENDED MISSION WITHOUT A CRITICAL FAILURE.

NOT A NEW PROBLEM

- EFFECTS OF DORMANCY A MAJOR CONCERN THROUGHOUT MILITARY HISTORY
  - FOOD
  - GUNPOWDER
  - AIRCRAFT
- SYSTEMS REMOVED FROM STORAGE EXPECTED TO PERFORM MISSION WITHOUT A CRITICAL MALFUNCTION

DORMANT RELIABILITY STATES

A FULL TREATMENT OF DORMANT RELIABILITY MUST CONSIDER SEVERAL POSSIBLE NON-OPERATING STATES WHICH RANGE FROM ACTUAL STORAGE THROUGH CAPTIVE CARRY. IN SHORT, DORMANT RELIABILITY APPLIES TO ANY STATE IN WHICH THE EQUIPMENT IS NOT OPERATING. IT IS POSSIBLE FOR A SYSTEM TO BE IN SEVERAL STATES AT THE SAME TIME. FOR EXAMPLE, THE AIR LAUNCHED CRUISE MISSILE IS POWERED UP PRIOR TO LAUNCH, BUT THE ENGINE DOES NOT FIRE UNTIL THE MISSILE IS RELEASED FROM THE CARRIER AIRCRAFT. IN THIS CASE, THE MISSILE IS PREDOMINATELY IN THE OPERATING STATE, BUT THE ENGINE IS DORMANT.

EACH NON-OPERATING OR DORMANT STATE POTENTIALLY EXHIBITS ITS OWN FAILURE MODES AND FAILURE RATES WHICH TYPICALLY DIFFER FROM FAILURE MODES AND FAILURE RATES EXPERIENCED IN THE OPERATING STATE.

DORMANT RELIABILITY STATES

COVERS SEVERAL STATES WHICH EXHIBIT POTENTIALLY DIFFERENT FAILURE MODES AND FAILURE RATES

- **STORAGE**
- **ALERT**
- **GROUND TRANSPORTATION**
- **CAPTIVE CARRY**

Impacts of Dormant Reliability

It is important to recognize the difference between logistics and operations impacts of dormant reliability. The logistics system will be concerned with all types of failures. Required spares provisioning, manpower requirements, and their associated costs throughout the system's life cycle are affected by dormant reliability and must be correctly estimated if the system is to be adequately supported. Logistics impacts are driven by the maintenance concept. A system which sits in storage for long periods with little periodic maintenance and few inspections will certainly impact the logistics system less than a system which is operated, inspected, and maintained daily.

The effects of dormant reliability on operations are more closely related to the capability of the system to function effectively. Basically, not all "failures" are critical. Those which are certainly affect operations; those which are not may impact operations, but they directly affect logistics. For example, Titan II and Minuteman ICBMs, which have several discrepancies waiting to be fixed, maintain daily alert ready for instant launch.

IMPACTS OF DORMANT RELIABILITY

- LOGISTICS
  - ALL FAILURES CORRECTED
  - SPARES PROVISIONING
  - MANPOWER REQUIREMENTS
  - LIFE CYCLE COSTS
- OPERATIONS
  - NOT ALL FAILURES CRITICAL
  - CAPABILITY TO OPERATE EFFECTIVELY

New Systems

Our new weapon systems are becoming more sophisticated, more complex, and more expensive. At the same time, we are facing ever shorter response times. Longer service lives for our weapon systems is a reality; e.g., Titan II, B-52, etc. To meet the requirement of rapid response after long periods of dormancy, reliability must be high and remain high throughout the life of the system.

NEW SYSTEMS

- MORE SOPHISTICATED, COMPLEX, EXPENSIVE
- SHORTER RESPONSE TIME
- LONGER SERVICE LIFE
- HIGHER RELIABILITY REQUIRED

THIS SLIDE DEPICTS SOME OF THE AIR FORCE SYSTEMS FOR WHICH DORMANT RELIABILITY IS OR WILL BE AN ISSUE ALONG WITH THEIR ASSOCIATED PERIODS OF DORMANCY. SIMILAR LISTS COULD BE CONSTRUCTED FOR OTHER SYSTEMS THROUGHOUT DOD; I.E., THE NAVY'S HARPOON MISSILE SYSTEM, THE ARMY'S PERSHING, ETC.

AIR FORCE SYSTEMS FOR WHICH DORMANT RELIABILITY IS AN ISSUE

SYSTEM	DORMANCY PERIOD
AIR LAUNCHED CRUISE MISSILE	12 MO FOR AIR VEHICLE 30 MO FOR ENGINE
GROUND LAUNCHED CRUISE MISSILE	30 MONTHS
MEDIUM RANGE AIR TO SURFACE MISSILE	36 MONTHS
MX	?
ADVANCED MEDIUM RANGE AIR TO AIR MISSILE	10 YEARS
WASP	10 YEARS
LOW LEVEL LASER GUIDED BOMB	10 YEARS
EXTENDED RANGE ANTI-ARMOR MUNITION	10 YEARS
IR MAVERICK	3 YEARS
SPARROW (AIM-7M)	30 MONTHS
IR GBU-15	3 YEARS
MINIATURE ANTI-SATELLITE SYSTEM	180 DAYS

CURRENT EMPLOYMENT CONCEPT

THE AIR FORCE, ALONG WITH OUR SISTER SERVICES, IS EXPLORING THE UTILITY OF A RELATIVELY NEW MAINTENANCE CONCEPT. THIS MAINTENANCE CONCEPT CALLS FOR A WOODEN ROUND (FULLY ASSEMBLED SYSTEM) TO BE PLACED IN DORMANT STORAGE FOR LONG PERIODS OF TIME WITH LITTLE OR NO MAINTENANCE OR INSPECTIONS. THE SYSTEM MAY BE REMOVED FROM STORAGE AND EXPECTED TO PERFORM ITS INTENDED MISSION WITHOUT INSPECTION OR PREPARATION AT ANY TIME DURING THE PERIOD OF DORMANCY.

THE BENEFITS TO THIS MAINTENANCE CONCEPT CAN BE SUBSTANTIAL. SINCE THE SYSTEM IS DORMANT THE MAJORITY OF THE TIME, MANPOWER REQUIREMENTS ARE REDUCED, FEWER SPARES ARE NEEDED, AND LIFE CYCLE COSTS ARE LOWERED.

HOWEVER, CONCERN ABOUT THE EFFECTS OF DORMANCY ON A SYSTEM'S OPERATIONAL CAPABILITY IS GROWING. FAILURES WHICH OCCUR IN STORAGE MAY REMAIN UNDETECTED UNTIL THE SYSTEM IS REQUIRED TO RAPIDLY RESPOND TO A MISSION REQUIREMENT. THEREFORE, DEVELOPMENT OF AN APPROACH FOR ASSESSING DORMANT RELIABILITY AS PART OF THE TEST AND EVALUATION PROCESS IS BECOMING INCREASINGLY IMPORTANT.

PRESENT EFFORTS TO ANALYZE DORMANT RELIABILITY INCLUDE SEVERAL DIFFERENT APPROACHES. THESE INCLUDE:

PIECE PART DORMANCY EVALUATION - THIS APPROACH INVOLVES "BUILDING UP" A SYSTEM DORMANT RELIABILITY FROM PARTS. IT IS SIMILAR TO THE MIL-HDBK-217C APPROACH FOR OPERATIONAL RELIABILITY. COMBINED ENVIRONMENTAL RELIABILITY TESTING (CERT) AND DORMANT FAILURE MODES AND EFFECTS ANALYSIS (FMEA) - THESE APPROACHES GO HAND-IN-HAND. A DORMANT FMEA WILL SHOW THE FAILURE MODES PECULIAR TO DORMANCY AND CERT MAY BE ABLE TO DUPLICATE THE STRESSES WHICH PREDOMINATE IN A DORMANT ENVIRONMENT. IF THE DORMANT FAILURE MODES SURFACE DURING CERT THEN A PROBLEM AREA HAS BEEN PINPOINTED. IT'S IMPORTANT TO NOTE THAT THIS APPROACH DOESN'T ALLOW DORMANT RELIABILITY PREDICTION.

WEIBULL MODELING - THE WEIBULL DISTRIBUTION IS VERY FLEXIBLE, ALLOWING INCORPORATION OF FAILURE RATES WHICH CHANGE WITH TIME. AS SUCH, IT MAY BE A GOOD CANDIDATE TO EXPLAIN THE DORMANCY FAILURE PROCESS.

SIMULATION - IF ENOUGH INFORMATION IS AVAILABLE TO QUANTIFY THE DORMANCY FAILURE PROCESS, THEN SIMULATION COULD BE EMPLOYED AT A SYSTEM LEVEL. UNFORTUNATELY, WE DON'T UNDERSTAND THE FAILURE PROCESS WELL ENOUGH TO EMPLOY SIMULATION, YET.

CONCLUSIONS

- DORMANT RELIABILITY IS AN AREA OF HIGH RISK FOR ANY SYSTEM WHICH EMPLOYS THE WOODEN ROUND CONCEPT COUPLED WITH LONG PERIODS OF DORMANT STORAGE

- PREDICTING DORMANT RELIABILITY AT THE SYSTEM LEVEL IS EXTREMELY DIFFICULT WITH CURRENT METHODOLOGIES

- PAST EFFORTS BY CONTRACTORS, DEVELOPERS, USERS AND TESTERS TO ADDRESS THE ISSUE HAVE BEEN INADEQUATE

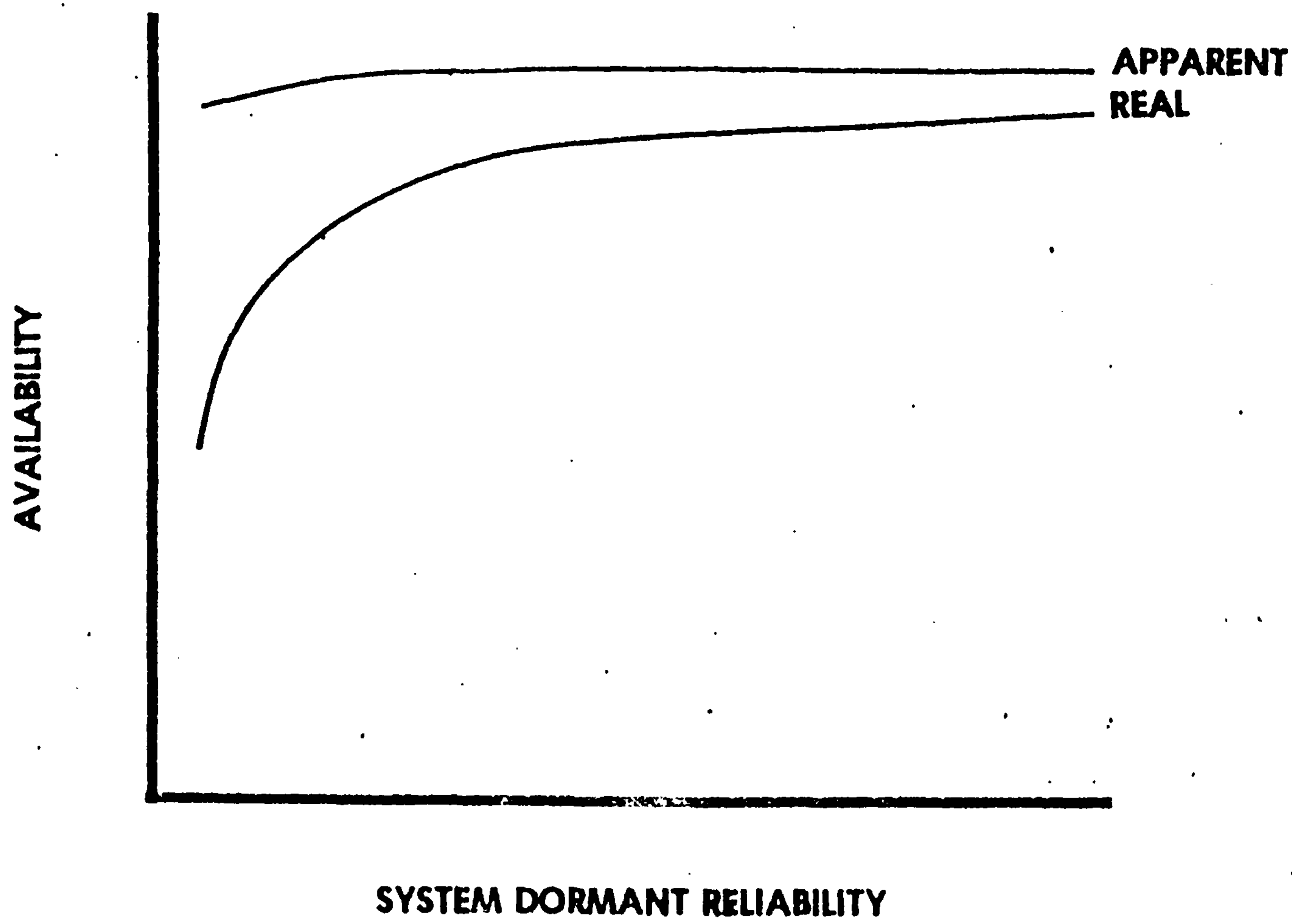
CONCLUSIONS

THE LACK OF SYSTEM LEVEL EMPIRICAL DATA ON DORMANT RELIABILITY AND RESULTING UNCERTAINTY OVER THE ABSOLUTE POINT ESTIMATES OF AVAILABILITY UNDERSCORE THE POTENTIAL RISKS ASSOCIATED WITH SYSTEMS WHICH EMPLOY THE WOODEN ROUND CONCEPT COUPLED WITH LONG PERIODS OF DORMANT STORAGE. THE RISKS IN PROCURING LARGE NUMBERS OF WEAPONS, EMPLOYING THEM IN THE DORMANT MODE AND DEPENDING ON THEM TO BE CAPABLE OF REACTING QUICKLY AND EFFECTIVELY WHEN NEEDED ARE SIGNIFICANT.

CURRENT METHODS OF PREDICTING DORMANT RELIABILITY AT THE SYSTEM LEVEL DO NOT LEND THEMSELVES TO USE DURING OPERATIONAL TESTING WHICH FOCUSES ON FULL SYSTEM TESTING DURING A RELATIVELY SHORT TIME PERIOD. CURRENT METHODOLOGIES ARE MORE ATTUNED TO PREDICTING DORMANT RELIABILITY AT THE PIECE PART OR COMPONENT LEVEL.

EFFORTS TO DATE IN THE CRITICAL AREA OF DORMANT RELIABILITY HAVE BEEN INADEQUATE. FOR THE ALCM, DORMANT RELIABILITY AND HENCE AVAILABILITY REMAIN UNKNOWN. ACCURATE ESTIMATES OF DORMANT RELIABILITY ARE NECESSARY TO PROVIDE DECISION-MAKERS WITH MEANINGFUL AVAILABILITY PROJECTIONS.

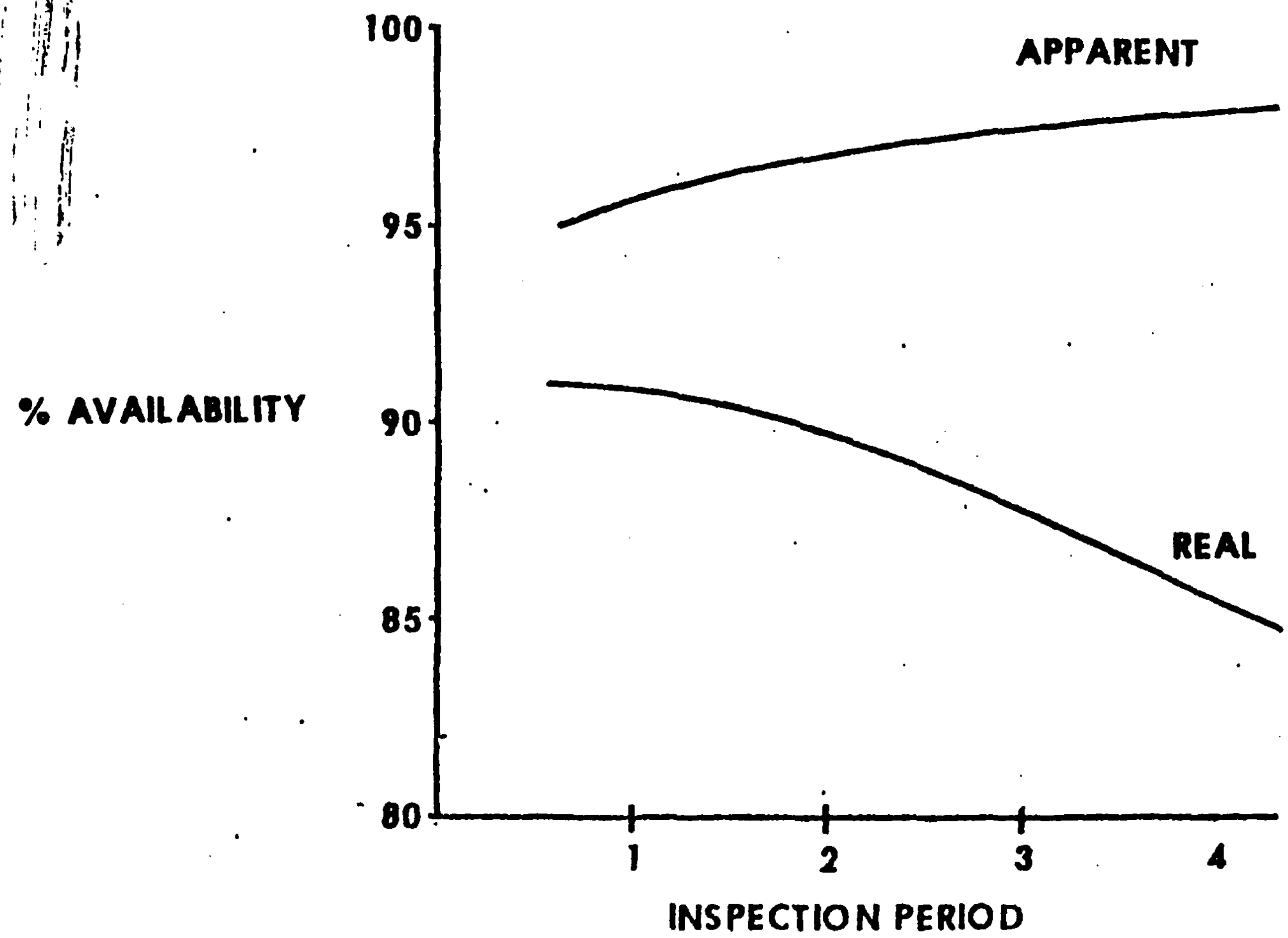
ALCM AVAILABILITY SENSITIVITY TO DORMANT RELIABILITY



ALCM Availability Sensitivity to Dormant Reliability

After a baseline availability estimate was made, we performed sensitivity analyses to determine the sensitivity of ALCM availability to changes in system dormant reliability. As expected, at very low failure rates (high dormant reliability), real and apparent availability are reasonably close and would be at acceptably high levels. However, as the failure rate increases (dormant reliability decreases), real and apparent availability diverge.

AVAILABILITY SENSITIVITY TO CHANGES IN INSPECTION PERIODS



THIS CHART GRAPHICALLY DEMONSTRATES THE DIFFERENCE BETWEEN APPARENT AND REAL AVAILABILITY. THE ANALYSIS IS FOR ILLUSTRATIVE PURPOSES ONLY.

CONSIDER THE AVAILABILITY LEVELS WHEN A ONE YEAR INSPECTION PERIOD IS FOLLOWED. SOME NUMBER OF MISSILES WILL BE APPARENTLY AVAILABLE. A CERTAIN NUMBER OF MISSILES WILL HAVE UNDETECTED FAILURES AS FAILURES ARE ONLY DISCOVDRED AT THE DISCRETE INSPECTION POINTS. THOSE MISSILES WITH UNDETECTED FAILURES ARE NOT REALLY AVAILABLE.

LENGTHENING THE INSPECTION PERIOD WILL ALLOW MISSILES WITH UNDETECTED FAILURES TO "LOG" MORE UP TIME BEFORE THOSE FAILURES ARE DISCOVERED. IN ACTUALITY, THE MISSILES APPEAR TO BE AVAILABLE BUT ARE NOT. IN TERMS OF REAL AVAILABILITY, LONGER INSPECTION PERIODS WILL ALLOW MISSILES TO "LOG' MORE DOWN TIME BEFORE THEY ARE DISCOVERED AND REPAIRED. IN THE EXTREME, AN INFINITE INSPECTION PERIOD WOULD DICTATE 100% APPARENT AVAILABILITY (FAILURES NEVER DETECTED) BUT REAL AVAILABILITY WOULD EVENTUALLY REACH ZERO SINCE THE FAILURES WHICH DID OCCUR WOULD NEVER BE REPAIRED AND EVENTUALLY WOULD CONSUME THE FLEET.

IN SHORT, ALL SYSTEMS EXHIBIT APPARENT AND REAL AVAILABILITY. THE DIFFERENCE BETWEEN THE TWO BECOMES CRITICALLY IMPORTANT WHEN THE MAINTENANCE CONCEPT FOR THE SYSTEM DICTATES LONG PERIODS OF DORMANCY (STORAGE, ALERT, ETC.) WITH FEW INSPECTIONS AND LITTLE OR NO SCHEDULED MAINTENANCE.

APPARENT AVAILABILITY

VS

REAL AVAILABILITY

APPARENT VS REAL AVAILABILITY

A BRIEF DISCUSSION OF APPARENT AND REAL AVAILABILITY IS REQUIRED TO FULLY APPRECIATE THE IMPACTS OF DORMANT RELIABILITY. THE AVAILABILITY WE ARE FAMILIAR WITH FROM OUR DAILY AIR FORCE EXPERIENCE CAN BE TERMED APPARENT AVAILABILITY. THIS MEASURE OF AVAILABILITY IS REDUCED ONLY WHEN A FAILURE IS DETECTED OR A SYSTEM IS DOWN FOR SCHEDULED MAINTENANCE, TRAINING, ETC. A DECREASE IN APPARENT AVAILABILITY MAKES A DEMAND ON THE LOGISTICS SYSTEM; I.E., A TECHNICIAN TO PERFORM A SCHEDULED INSPECTION, A SPARE PART TO REPAIR A FAILURE, ETC.. APPARENT AVAILABILITY IS THAT FIGURE REFLECTED ON THE WING STATUS BOARD. IT IS WHAT WE THINK WE HAVE AVAILABLE IN CASE IT IS NEEDED.

REAL AVAILABILITY MAY DIFFER SUBSTANTIALLY FROM APPARENT AVAILABILITY. IN THE REAL WORLD, AVAILABILITY IS DECREMENTED WHEN THE FAILURE OCCURS, NOT WHEN THAT FAILURE IS DETECTED. A WEAPON SYSTEM MAY SIT IN DORMANT STORAGE FOR LONG PERIODS OF TIME BEFORE A CRITICAL FAILURE IS DISCOVERED. THE SYSTEM WOULD BE CONSIDERED APPARENTLY AVAILABLE SINCE IT WAS GOOD WHEN IT WENT INTO STORAGE AND WE HAVE NO REASON TO BELIEVE OTHERWISE UNTIL A FAILURE IS DETECTED. THE UNCERTAINTY OVER WHETHER A SYSTEM IS REALLY AVAILABLE FOR NOT DURING THE LONG PERIODS BETWEEN "HEALTH CHECKS" BRINGS INTO FOCUS THE NEED TO FULLY UNDERSTAND DORMANT RELIABILITY AND TO ASSESS ITS IMPACTS ON SYSTEMS WHICH SPEND A SIGNIFICANT PORTION OF THEIR LIVES IN SOME FORM OF DORMANCY.

LIMITATIONS OF CURRENT APPROACHES

- EXISTING METHODOLOGIES NOT DIRECTLY APPLICABLE TO OT&E
  - GEARED TO INHERENT RELIABILITY
  - ACCOMPLISHED AT THE PIECE PART LEVEL
- K FACTORS OFTEN USED TO VALIDATE SPECIFICATION REQUIREMENTS
  - HIGHLY SYSTEM DEPENDENT
  - GENERALLY APPLIED TO PIECE PARTS
- ACTUAL MEASUREMENT IS A LONG TERM PROCESS

LIMITATIONS OF CURRENT APPROACHES

METHODOLOGIES CURRENTLY USED TO PREDICT RELIABILITY (OPERATING OR DORMANT) DO NOT LEND THEMSELVES TO USE IN THE OT&E ENVIRONMENT. EXISTING METHODOLOGIES ARE GEARED TO INHERENT RELIABILITY WHICH INCLUDES ONLY THE EFFECTS OF DESIGN AND APPLICATION (ASSUMES IDEAL OPERATION AND SUPPORT ENVIRONMENT) RATHER THAN FIELD RELIABILITY WHICH IS EXPERIENCED IN THE "REAL WORLD" OPERATION AND SUPPORT ENVIRONMENT. ADDITIONALLY, CURRENT METHODS ARE TYPICALLY APPLIED AT THE PIECE PART OR COMPONENT LEVEL. ANALYSIS AND INTERPRETATION OF RESULTS BECOMES EXTREMELY COMPLEX WHEN DEALING WITH A SYSTEM OR SOPHISTICATED SUBSYSTEM AS EACH COMPONENT EXHIBITS UNIQUE CHARACTERISTICS FOR A GIVEN SET OF CONDITIONS. THESE CHARACTERISTICS DO NOT CHANGE IN DIRECT PROPORTION TO EACH OTHER AS STRESS LEVELS OR ENVIRONMENTS CHANGE.

FAILURE RATE MODIFICATION FACTORS (K FACTORS) ARE OFTEN USED TO VALIDATE SPECIFICATION REQUIREMENTS WHEN LITTLE OR NO TESTING IS EXPECTED FOR A PARTICULAR ENVIRONMENT. K FACTORS ARE USED AT THE SYSTEM LEVEL EVEN THOUGH THEY ARE HIGHLY SYSTEM DEPENDENT AND ARE MORE APPROPRIATELY APPLIED AT THE PIECE PART LEVEL.

ACTUAL MEASUREMENT OF DORMANT RELIABILITY IS NECESSARILY A LONG TERM PROCESS. EVEN DURING ACTUAL MEASUREMENT, IT IS DIFFICULT TO KNOW WHEN A FAILURE HAS OCCURRED AND WHAT CAUSED THE FAILURE (AGE, TRANSPORTATION, HANDLING, ETC.). IN ADDITION TO THESE ASPECTS, DATA SYSTEMS ARE NOT STRUCTURED TO CAPTURE THE ELEMENTS NECESSARY FOR TESTING OR VALIDATION NOR DO THEY ACCURATELY ACCOUNT FOR TIME OR AGE--FACTORS CENTRAL TO THE DORMANCY ISSUE.

CURRENT METHODOLOGIES

- PARTS COUNT AND STRESS ANALYSIS PREDICTION
- FAILURE RATE MODIFICATION FACTORS (K FACTORS)
- ACCELERATED TESTING
- REAL-TIME OR SURVEILLANCE TESTING

CURRENT METHODOLOGIES

CURRENT TECHNIQUES FOR ESTIMATING DORMANT RELIABILITY GENERALLY FALL INTO THREE BROAD CATEGORIES OF ANALYTICAL PREDICTION AND ONE CATEGORY OF ACTUAL MEASUREMENT:

1) THE PARTS COUNT RELIABILITY PREDICTION METHOD ASSUMES THAT THE EQUIPMENT FAILURE RATE IS A FUNCTION OF THE FAILURE RATES OF ITS COMPONENTS OR PARTS.

2) FAILURE RATE MODIFICATION FACTORS (GENERALLY KNOWN AS K FACTORS) ARE USED TO PREDICT UNKNOWN FAILURE RATES IN ONE ENVIRONMENT FROM KNOWN FAILURE RATES IN ANOTHER ENVIRONMENT. K FACTORS ASSUME THAT A RELATIONSHIP EXIST BETWEEN FAILURE RATES IN DIFFERENT ENVIRONMENTS AND THAT THE RELATIONSHIP CAN BE EXPRESSED AS A NUMBER.

3) ACCELERATED OR OVERSTRESS TESTING IS A COMMON METHOD USED TO OBTAIN FAILURE RATE DATA IN A RELATIVELY SHORT TIME PERIOD.

4) REAL-TIME TESTING IS NOT ACCELERATED AND, WITH RESPECT TO RELIABILITY TESTING, IS GENERALLY REFERRED TO AS SURVEILLANCE TESTING.

TYPICALLY, THESE PROGRAMS ARE DESIGNED TO PROVIDE ENGINEERING FIXES FOR A SYSTEM AND NOT NECESSARILY TO PROVIDE THE OPERATIONAL TESTER WITH A READY METHOD FOR PREDICTING MATURE SYSTEM RELIABILITY.

CURRENT EMPLOYMENT CONCEPT

- MAINTENANCE CONCEPT
  - WOODEN ROUND
  - LONG PERIODS OF DORMANT STORAGE
  - PERIODIC MAINTENANCE REDUCED OR ELIMINATED
- BENEFITS
  - REDUCED MANPOWER REQUIREMENT
  - FEWER SPARES
  - LOWER LIFE CYCLE COST
- CONCERNS
  - EFFECTS OF DORMANCY
  - METHOD TO ASSESS EFFECTS OF DORMANCY

PRESENT EFFORTS

- PIECE PART DORMANCY EVALUATION
- COMBINED ENVIRONMENTAL RELIABILITY TESTING (CERT)
- DORMANT FAILURE MODES AND EFFECTS ANALYSIS
- WEIBULL MODELING INVESTIGATION
- SIMULATION

THE PRIMARY PROBLEM WITH MODELING DORMANT RELIABILITY IS A LACK OF GOOD DORMANCY DATA. MOST DATA BASES ARE GEARED TOWARD MEASURING OPERATIONAL RELIABILITY. WITHOUT DATA AN ANALYST MUST VERIFY HIS MODEL THROUGHOUT THE DORMANCY PERIOD, WHICH IS OFTEN SEVERAL YEARS.

PROBLEMS

- DATA IS LIMITED
- DATA BASES ARE NOT COMPARABLE
- MODEL VALIDATION REQUIRES SEVERAL YEARS

RECOMMENDATIONS

THE FIRST STEP IN ADDRESSING THE DORMANT RELIABILITY ISSUE IS TO RECOGNIZE THE POTENTIAL RISKS ASSOCIATED WITH UNKNOWN AVAILABILITY OF OUR WEAPON SYSTEMS.

ATTACKING THE PROBLEM "UP FRONT" WITH RESOURCES NECESSARY TO ESTABLISH A PROGRAM TO PREDICT DORMANT RELIABILITY IS THE ONLY WAY TO OBTAIN ACCURATE AVAILABILITY ESTIMATES BEFORE A NEW WEAPON SYSTEM IS EMPLOYED. THE DORMANT RELIABILITY ISSUE SHOULD BE CONSIDERED DURING THE CONCEPTUAL PHASE OF NEW WEAPON SYSTEM DEVELOPMENT. FOR EXAMPLE, A FAILURE MODES AND EFFECTS ANALYSIS (FMEA) SPECIFICALLY ADDRESSING THE DORMANT MODE WOULD PROVIDE VALUABLE INSIGHT INTO POTENTIAL PROBLEMS RELATING TO DORMANT RELIABILITY. (WE HAVE REQUESTED SUCH AN ANALYSIS ON THE GLCM).

AFTER THE SYSTEM IS PLACED IN THE ACTIVE INVENTORY, FURTHER TESTING AND ANALYSIS WILL HELP DEFINE DORMANT RELIABILITY PARAMETERS, YIELD A HIGHER CONFIDENCE IN OUR ABILITY TO PREDICT A SYSTEM'S AVAILABILITY, AND FOSTER TRUST IN THE OPERATIONAL CAPABILITY OF OUR FRONT LINE WEAPON SYSTEMS. HOWEVER, A METHOD OF CAPTURING DATA PERTINENT TO THE DORMANCY ISSUE (TIME TO FAILURE, CAUSE OF FAILURE, DORMANCY HISTORY OF ITEM, ETC.) MUST BE DEVELOPED AND USED FOR OPERATIONAL (FIELDED) SYSTEMS. WE NEED TO KNOW OUR WEAPON SYSTEMS ARE REALLY AVAILABLE WHEN WE NEED THEM.

RECOMMENDATIONS

- RECOGNIZE POTENTIAL RISKS

- DEVELOP METHODOLOGY TO PREDICT DORMANT RELIABILITY AT THE SYSTEM LEVEL DURING THE DESIGN PHASE

- CONTINUE TESTING AND ANALYSIS WHEN ITEM PLACED IN THE ACTIVE INVENTORY

THE GEORGE WASHINGTON UNIVERSITY
School of Engineering and Applied Science
Institute for Management Science and Engineering

Program in Logistics

THE AFLMC BIBLIOGRAPHY

A SUMMARY FOR LOGCAS 82

by

W. H. Marlow

Serial 72441
11 March 1982

1. Introduction

The objectives of our effort were to review the literature for the past 25 years on logistics capability and readiness assessment, to prepare a bibliography of relevant works, to recommend readiness definitions, to develop a taxonomy of logistics related capability assessment techniques, and to classify the latter techniques.

The final report is Reference [1] and the Air Force Logistics Management Center (AFLMC) Bibliography, briefly the bibliography, is presented in Reference [2]. It contains 721 references on logistics capability and readiness assessment, all of which are classified according to a four-way taxonomy: kind of readiness, methodological approach, military service, and military unit. In the present report, we briefly describe the bibliography, our technical reports, the taxonomy, special keywords, and certain other features such as entries for joint authors, source organization, Defense Logistics Studies Information Exchange (DLSIE) identification numbers, and so on. References [2] through [6]

furnish complete documentation of results. For convenience, abstracts for References [1] through [6] are collected together as Appendix I.

2. A Readiness Taxonomy

We sought a taxonomy of logistics-related capability assessment techniques so as to classify the contents of the works in the bibliography. Our objective was to provide for effective utilization of the large body of information represented by the many papers and reports in the bibliography.

We classified all works in the bibliography [2] according to a four-way taxonomy, namely,

Kind of readiness

Methodological approach

Military service

Type of military unit

We provided answers, in the form of reserved words, to the following questions.

(1) What kind of readiness appears?

(2) How is the assessment done?

(3) Which branch of service is involved?

(4) Whose readiness is being assessed?

Our readiness classification (1) has four principal categories with qualitative definitions as follows.

Personnel readiness is the status of the personnel of a military unit as being able to satisfy certain standard requirements.

Materiel readiness is the status of the systems, equipment and supplies of a military unit as being able to satisfy certain standard requirements.

Mission readiness is the status of a military unit as being able to perform the required standard tasks for a specific operation.

> Combat readiness is the status of a military unit as being able to perform the required standard tasks for its designated missions.

Notice the common feature of specific standards against which status is to be determined. In general, combat readiness concerns overall demands for all or at least some substantial number, of the different things it could be expected to do. Mission readiness concentrates on some one specific operation that the unit could be expected to perform. Materiel readiness concerns all of the non-human resources the unit needs to do something quite specific. Personnel readiness deals with human contributions and it is complementary to materiel readiness.

The second classification, methodological approach, also has four principal categories.

Analytic
Empirical
Simulation
Simulated combat

Qualitative definitions are as follows.

A methodological approach is called analytic if it attempts to develop a theoretical model or models concerning relationships between measures of readiness and other characterizing variables. An approach is called empirical if it is designed to study the relationships between readiness measures and other pertinent variables by constructing ad hoc statistical models based on the correlations among the variables. An approach is called simulation if it is based on data gathered by computer simulation. An approach is called simulated combat if it is designed to generate readiness measures based on combat maneuvers of military units. As a practical matter, and specifically to identify special methodological approaches found in the bibliography, we have enlarged the list by five straightforward categories.

Critique
Exposition
Proposal
Regulation
Survey

Each of these identifies a useful class of contributions to the state of affairs in logistics capability and readiness assessment.

The third classification, military service has seven categories.

Army
Navy
Air Force
Marine Corps
Department of Defense
Joint
All

The fourth classification, type of military unit, has 45 categories as follows.

Air Control System
Aircraft Fleet
Aircraft Squadron
Aircraft Wing
Aircraft
Amphibious Brigade
Armored Units
Base
Battalion Command Group
Battalion
Brigade
Combat Battalion
Communications
Corps
Department
Depot
Division
Facilities
Fleet
Force
General
Helicopters
Infantry Battalion
Infantry
Maintenance Squadron
Major Command
Major Weapon System
Manager
Merchant Marine
Missile Squadron
Missile
Plant
Reserve
Satellite
Ship
Shop
Strike Force
Supply System
Support Unit
Tank Force
Task Force
Test System
Theater
Vehicle Fleet
Vehicle

3. A description of the bibliography

The complete list of 141 keywords is as follows.

A-10
A-4
A-6
A-7
Advanced naval vehicle
Air Force Logistics Command
Aircraft carrier
Availability
Avionics shop
ACS Force Development
AEGIS
AFIRMS
AH-1
AMORE
AR 220-1
AWACS
Bibliography

Budget
BGM-34C
BLSS
C-12
C-130
C-141
C-5
Capability
Combat service support
Communications
Cruiser
CBR
Defense Communications
Defense Logistics Agency
Definitions
Destroyer
Distribution
DARCOM
DYNA-METRIC
Effectiveness
Evaluation
F-105
F-106
F-111
F-14
F-15
F-16
F-18
F-4
Facilities
Factor analysis
Fighter aircraft
Flight simulator
Float
Force planning
Forklift
Fuel
FBM Weapon System
FF-1052
FOCAS
FORSCAP
FORSTAT
Ground support equipment
Hawk
Helicopter
Inspection
Linear programming
LAMPS
LCMS
LCOM
LOGSAM
Maintenance
Management
Military essentiality
Military Airlift Command
Minuteman
Missile equipments
Mission area analysis
Mobilization
Modernization
Modifications
Munitions
MARIS
MCCRES
METRI
METRIC
MOD-METRIC
Naval Air Training Command
Networks
NATO
NORM
NORS
Optimization
Ownership costs
OPSTAT
P-3
Pacific Command
Prediction
Prepositioning
Procurement
Production
Production function
Provisioning
PLANET
POMCUS
PRIMAR
Readiness standards
Regression
Reliability
Repair
Replacement
Reporting
Research and development
REDCON
Sortie generation rate
Sparrow
Strategic aircraft
Submarine
Supply
System dynamics
SAMSON
SCAM

Tactical air control system	TAC TURNER
Tactical aircraft	TRACES
Tactical wing	TSAR
Tactical Air Command	TSARINA
Testing	UH-1
Theater base	USAEUR
Theory	USAFE
Training	Vehicle
Transport fleet	Warranty
Transportation	WRM
Trident	WRSK

Assigments of keywords to works are shown in References [3] and [4]. Note that the keywords in [5] are DLSIE keywords.

A total of 819 different authors are represented, as shown in the Author Citation List in [3]. The number of different source organizations, also listed in [3], is 185. Years of publication are distributed as follows.

Years	Count	%	Cumulative %
1950-1959	7	1	1
1960-1969	134	19	20
1970-1974	145	20	40
1975	46	6	46
1976	51	7	53
1977	69	10	63
1978	73	10	73
1979	74	10	83
1980	69	10	93
1981	53	7	100
	721	100	

Counts of kinds of readiness are as follows.

	Count	%
Combat readiness	142	20
Materiel readiness	426	59
Miscellaneous readiness	29	4
Mission readiness	60	8
Personnel readiness	48	7
Production readiness	16	2
	721	100

Approaches appear as follows.

	Count	%
Analytic	195	27
Critique	76	11
Empirical	194	27
Exposition	82	11
Proposal	11	1
Regulation	10	1
Simulated combat	5	1
Simulation	119	17
Survey	29	4
	721	100

Counts for military services are as follows.

Army	140	19
Navy	187	26
Air Force	203	28
Marine Corps	20	3
Department of Defense	37	5
Joint	8	1
All	126	18
		100

4. Recommendations

We made four general recommendations.

The AFLMC Bibliography should be enhanced, audited, published, and used as a standard tool.

A handbook of models and source data should be created.

There should be programmed interaction and collaboration between the researchers and the military who are charged with the responsibility for developing assessment techniques.

Specific standard requirements should be formulated for given military units, these units should be tested on their ability to satisfy the requirements, and the results should be used to assess readiness.

REFERENCES

[1] BARZILY, Z., W. E. CAVES, W. H. MARLOW, A. RAO and S. ZACKS (1981a). Final report on the AFLMC Bibliography. Technical Paper Serial T-455.

[2] BARZILY, Z., W. E. CAVES, W. H. MARLOW, A. RAO and S. ZACKS (1981b). The AFLMC Bibliography. Technical Paper Serial T-456.

[3] CAVES, W. E. and W. H. MARLOW (1981a). Citation lists from the AFLMC Bibliography. Technical Paper Serial T-457.

[4] CAVES, W. E. and W. H. MARLOW (1981b). The AFLMC Working Bibliography. Technical Paper Serial T-458.

[5] CAVES, W. E and W. H. MARLOW (1981c). DLSIE printouts for the AFLMC Biblography. Technical Paper Serial T-459.

[6] CAVES, W. E. and W. H. MARLOW (1981d). Computer programs for the AFLMC Bibliography. Technical Paper Serial T-460.

Appendix I

Abstract Pages

for

Serials

T-455

T-456

T-457

T-458

T-459

T-460

the annual maintenance summary.

a. Inputs:

1) Non-break Sorties: The total number of sorties completed during the year which did not result in a grounding malfunction (code 3) upon landing. This is a surrogate measure of aircraft reliability.

2) Fix Sorties: The number of code 3 sorties during the year where the aircraft involved were returned to mission capable status within eight hours of landing. This is a surrogate measure of aircraft maintainability and repair capability.

The input factors are not what one would typically consider to be inputs. They were chosen as inputs because of their relationship to the output. Significant increases in these inputs should cause increases in the output if the unit is efficient. If the inputs are increasing and outputs are not, unit efficiency is decreasing; if outputs are increasing and inputs remain unchanged, then the unit is gaining in efficiency. Admittedly the exact relations between the inputs and the output are unknown, but DEA enables useful comparisons even under these circumstances without violating any mathematical or logical principles.

b. Output--Mission Capable Maintenance Aircraft-Days: The average number of possessed aircraft during the year multiplied by the number of days in the year and then multiplied by the Mission Capable Maintenance Rate.

Table 1 shows the input/output data and resulting DEA efficiency measured for seven of the thirty-two units evaluted.

Table 1

UNITS	Mission Capable Maintenance Aircraft-Days	Non-Break Sorties	Fix Sorties	Efficiency (h_o)
A	11063	6519	239	1.000
B	15679	5211	588	1.000
C	19186	3756	1384	1.000
D	10997	6173	306	.928
E	11190	6527	1109	.493
F	18020	8275	2293	.500
G	12497	6978	2884	.350

The solution of this non-linear, ratio problem can be obtained by transforming it into an equivalent linear problem and then solving. The mathematical theory and proof governing this transformation can be found in the article by Charnes, Cooper and Rhodes [3] and will not be repeated in this paper. But there are a few observations which are worth noting here.

First, as can be clearly seen in line (a), the efficiency measure, h_o is a ratio much like the engineering measure. In fact, it can be shown that the engineering measure using the "perfect" unit as a member of the comparison set is a special case of the above formulation. Secondly, the constraints of line (b) insure that the maximum achievable value of h_o is 1. And, the multipliers, W_r and U_i, will be computed in such a way that the unit being evaluated will receive the highest h_o value possible, i.e., no other feasible values of these multipliers will produce a higher efficiency rating for DMU_o. Finally, the requirement that multipliers be positive (line (c)) insures that all inputs and outputs have an effect on the final rating.

A fact not so readily apparent in the formulation is that two DMU's can be rated efficient even when the patterns of their inputs and outputs are quite different. Differences in managerial strategy and emphasis are treated fairly by the DEA model. Each unit is compared to others in the set which have similar input/output patterns, i.e., those units in its "neighborhood."

Example

The data used in this analysis came from the Monthly Maintenance Summary (FY 81 Wrap-up) of Tactical Air Command. Thirty-two fighter and reconnaissance units were chosen for evaluation representing 13 weapon systems (Mission-Design-Series), two numbered Air Forces, and three missions (operations, training and testing).

TAC has not verified the data nor reviewed the results; thus, wing identities will be kept anonymous. This limited example will, however, suffice to illustrate the power of the DEA technique, and the use of the actual data gives the results more meaning.

This example analysis focuses on the efforts of combat units to maintain a high percentage of mission capable aircraft. The following three input/output values were derived for each of the 32 units from data in

4. DATA ENVELOPMENT ANALYSIS (DEA)

There are many publications available which thoroughly document the theory and application of DEA. We will summarize only part of this reference material, making a few pertinent observations about the DEA model, and then present a simple example based on actual Air Force data. The reader interested in a more thorough review of past work is encouraged to read the articles referenced at the end of this paper.

The DEA Model

Suppose one wishes to compare the efficiency of n decision making units each of which uses m inputs of the same type and produces s outputs of the same type. Using the notation conventions of DEA's developers, A. Charnes, W. W. Cooper and E. Rhodes [3], let:

X_{ij} = the amount of input type i used by DMU j during the period of observation, i = 1,2,..., m and j = 1,2,..., n

Y_{rj} = the amount of output type r produced by DMU j during the period of observation, r = 1,2,..., s and j = 1,2,... n

X_{io} = the amount of input type i used by the unit whose efficiency is to be measured. The "o" subscript means that one of the n units has been singled out for evaluation. Each DMU in turn will be so evaluated.

Y_{ro} = the amount of output type r used by DMU_o

h_o = the efficiency value sought for DMU_o

U_i = the multipliers for each input type which will be determined by solution of the model

W_r = the multipliers for each output type r which will be determined by solution of the model

The following model formulation is used to determine h_o, the efficiency rating of any specified DMU_o, from among the j = 1,2,...n units:

maximize
$$h_o = \frac{\sum_{r=1}^{s} W_r Y_{ro}}{\sum_{i=1}^{m} U_i X_{io}} \qquad (a)$$

subject to
$$\frac{\sum_{r=1}^{s} W_r Y_{rj}}{\sum_{i=1}^{m} U_i X_{ij}} \leqslant 1 \qquad j = 1,2,\ldots n \qquad (b)$$

$$W_r\ U_i > 0 \quad \text{for every } i,\ r \qquad (c)$$

a. Measurement difficulties and inaccuracies are a major concern.

b. The time intervals for measuring and comparing efficiency of of operations is important when output requirements vary a great deal.

c. Variances in the designed operational capability of the units must be carefully considered. For example, comparing the efficiency of a small motor used in a clock to one used to drive a trolley would not be useful. Similarly, it would be very difficult, and perhaps fruitless, to compare the efficiency of a small helicopter detachment and a large airlift wing. On the other hand, given that two alternative units of the same type are designed to produce the same outputs, then an efficiency comparison is quite useful in determining which one is best.

d. Environmental conditions must be taken into account. In engineering, changes in environmental factors such as temperature and moisture can cause changes in operating characteristics of units. In the Air Force, weather plays a significant role in equipment maintenance and sortie production. If efficiency comparisons are to be fair, conditions such as these must be accounted for.

There are a few additional problems of assessing not-for-profit organizational efficiency which engineers do not face in evaluating mechanical systems. Human organizations frequently have inputs and outputs which are imprecise, vague, and often very difficult to measure. For example, what does the input "workforce" mean and how should it be measured? How would one measure "effective combat sorties?" Additionally, multiple inputs and outputs of public organizations are seldom (if ever) expressed in common units of measure, and the causal relationships linking inputs to outputs are not usually formulated. Often organizations rely on measures which are production correlates or surrogates for several variables, where relationships are implied but not proven.

Before the development of the DEA model, which will be presented in the next section, the difficulties of developing and using comprehensive efficiency models in public agencies appeared to be insurmountable. Partial measures were used instead. But DEA now offers a way to combine multiple inputs and outputs into a single measure, and meaningful analytical results can now be obtained with much less difficulty.

According to the Encyclopedia of the Social Sciences [4]:

> "Efficiency in the sense of a ratio between input and output, expenditure and income, cost and resulting pleasure, is a relatively recent term. In this specific sense it became current in engineering only during the latter half of the nineteenth century and in business and in economics only since the beginning of the twentieth."

As an illustration of this usage, consider the following formulas which are frequently found in engineering books:

$$\text{Efficiency} = \frac{\text{Output}}{\text{Input}} = \frac{\text{Input-Losses}}{\text{Input}} \quad (1)$$

From the engineering viewpoint, outputs and inputs are both measured in terms of energy and the law of conservation of energy requires that the output of useful energy must be less than the input. For example, a "perfect" electric motor which draws 746 watts of electric power would be able to produce one horsepower of mechanical power; i.e., no energy is lost in the transformation in which case formula (1) would yield

$$\text{Efficiency} = \frac{\text{Output}}{\text{Input}} = \frac{\text{Input-No Losses}}{\text{Input}} = \frac{\text{Input}}{\text{Input}} = 1$$

Unfortunately, the idea of perfect efficiency is not applicable to social organizations, including combat wings. If one were able to specify the maximum achievable sortie production of a tactical fighter wing, given certain levels of resource consumption, then the efficiency of the wing could be measured by dividing the actual sortie production by the maximum achievable sortie production. But no production function has yet been developed which can forecast maximum sortie potential given the multitude of possible input (resource) combinations and environmental conditions. Thus, the Air Force in assessing its units must rely on "relative" measures of efficiency from empirically based comparisons of input and output measures.

We can, however, gain some insight into the criterion of efficiency by examining it in the engineering context. The following principles seem applicable to both engineering and social systems from the standpoint of comparing efficiencies of units:

variations that might affect combat potential. The measure to be used for these purposes should be theoretically and logically justified in its ability to evaluate the actual achievement of each unit relative to the maximum achieved by other comparable units. The measure should be fair and take into account controllable and uncontrollable variables. It should on the one hand provide a convenient summary in the form of a single measure of efficiency and on the other hand make it possible to detect inefficiencies and direct attention to the relevant factors for correcting these inefficiencies. It should further reveal possible trade-offs between different inputs and outputs, even when a wing is operated efficiently, and should indicate opportunities for improvement. DEA has all of these capabilities, but further work is required to evaluate its applicability, along with related models and methods of analysis, for use by the USAF. But before describing the DEA model and what it can do, we must first clarify what role the criterion of efficiency should play in monitoring and managing organizations.

3. CRITERION OF EFFICIENCY

"Efficiency" and "Effectiveness" as used in this paper are not conflicting terms. Any past separation of these concepts resulted from misuse of the efficiency criterion. In public service organizations, where goals are complex and difficult to quantify, there is a tendency to place unwarranted emphasis on only one aspect of efficiency, achieving current production at lower costs. In some cases, reductions in cost (eliminating manpower, reducing overhead, etc.) have been pursued without explicit regard for the impact on effectiveness. The true criterion of efficiency requires consideration of changes in both inputs and outputs. In fact, efficiency will increase if the effectiveness of an organization increases through better use of existing resources. Sometimes additional resources (higher costs) might be justified if these newly acquired inputs will be used efficiently and if the value of the resultant increase in effectiveness outweighs the added costs.

1. INTRODUCTION

A. Charnes, W. W. Cooper, A. Bessent, and W. Bessent (all of The University of Texas at Austin), together with E. Rhodes (State University of New York) have developed and tested a new method called DEA (Data Envelopment Analysis) for measuring and evaluating the efficiency of not-for-profit enterprises in a variety of contexts. The latter include applications to both military and civilian problems which have all involved multiple-output as well as multiple-input situations for each of a variety of managerial Decision Making Units--hereafter called DMU's--where a measure of efficiency was desired which would not require *a priori* weights or similar devices to arrive at a single overall (scalar) measure of efficiency for each such DMU. Furthermore, the models from which this measure is derived also provide details on the sources and relative magnitudes of any inefficiencies along with information on trade-offs and other information needed for improved decision making.

Air Force units (DMU's) are encouraged to maintain peak readiness and maximize the military capability of their highly complex, multi-input, multi-output operating systems. DEA with a few modifications appears to have significant potential for near term use by the military in assessing and managing the many facets of efficiency and capability. It enables the unified analysis of multiple technical, economic and effectiveness measures in contrast to past management and analysis techniques which relied too heavily on "partial" measures of productivity, cost effectiveness, maintainability, etc. This paper examines the criterion of efficiency, briefly describes the DEA model, and suggests areas of further study.

2. PROBLEM

The public expects the military services to derive the maximum possible capability and combat readiness from the forces which were paid for with tax dollars. Thus, commanders and resource managers in the Air Force need a tool of measuring the efficiency of combat units which simultaneously takes into account many of the factors including mix and other

Research Report EPC 002

MEASURING THE EFFICIENCY OF AIR FORCE COMBAT UNITS

by

Charles T. Clark
Major, USAF

March 1982

THE GEORGE WASHINGTON UNIVERSITY
School of Engineering and Applied Science
Institute for Management Science and Engineering

Program in Logistics

Abstract
of
Serial T-460
31 December 1981

COMPUTER PROGRAMS
FOR THE
AFLMC BIBLIOGRAPHY

by

W. E. Caves
W. H. Marlow

The Air Force Logistics Management Center (AFLMC) Bibliography contains 721 references on logistics capability and readiness assessment. All data reside in the AFLMC Working Bibliography which is a collection of 80 character card image records. The present report defines the record format, describes both special and support computer programs, and presents some typical run sequences. Almost any computer that can edit 80 character records could be used to process the Working Bibliography, perhaps by working on subcollections of the entire 760,000 character collection. The final report on the entire effort is contained in Serial T-455.

Research Supported by
Subcontract SCEEE/AFLMC/80-0001
Air Force Contract F01600-80-D0299

THE GEORGE WASHINGTON UNIVERSITY
School of Engineering and Applied Science
Institute for Management Science and Engineering

Program in Logistics

Abstract
of
Serial T-459
31 December 1981

DLSIE PRINTOUTS FOR THE AFLMC BIBLIOGRAPHY

by

W. E. Caves
W. H. Marlow

Defense Logistics Studies Information Exchange (DLSIE) identification numbers (LD numbers) are available and are included for about 450 out of 721 Air Force Logistics Management Center (AFLMC) Bibliography entries. This facilitates ordering microfiche copies and other pertinent materials from DLSIE. With regard to the latter, the present report consists of a complete set of photo-reduced copies of DLSIE bibliography pages and DLSIE model abstracts both with AFLMC Bibliography labels affixed. These DLSIE printouts furnish abstracts of reports, DLSIE keywords, and additional information on the great majority of works that do not appear in the published literature. The final report on the entire effort is contained in Serial T-455.

Research Supported by

Subcontract SCEEE/AFLMC/80-0001
Air Force Contract F01600-80-D0299

THE GEORGE WASHINGTON UNIVERSITY
School of Engineering and Applied Science
Institute for Management Science and Engineering

Program in Logistics

Abstract
of
Serial T-458
31 December 1981

THE AFLMC WORKING BIBLIGRAPHY

by

W. E. Caves
W. H. Marlow

The Air Force Logistics Management Center (AFLMC) Working Bibliography contains all 80 character card image records pertaining to reference works in the (formal) AFLMC Bibliography. In the present report, reference works appear in sequence by AFLMC document number and each page treats two numbers. In practice it is convenient to print one 4x6 card per document number. Contents of the special column 5 entries (A for author, K for keyword, and so on) are displayed in a single column. The final report on the entire effort is contained in Serial T-455.

Program in Logistics

Subcontract SCEEE/AFLMC/80-0001
Air Force Contract F01600-80-D0299

THE GEORGE WASHINGTON UNIVERSITY
School of Engineering and Applied Science
Institute for Management Science and Engineering

Program in Logistics

Abstract
of
Serial T-457

CITATION LISTS FROM THE AFLMC BIBLIOGRAPHY

by

W. E. Caves
W. H. Marlow

Reference works in the Air Force Logistics Management Center (AFLMC) Bibliography are identified by citation records consisting of authors' names and year of publication. The present report consists of four lists of such records. The Keyword Citation List is in alphabetic sequence by keyword with all corresponding citation records appearing in alphabetic sequence. The Taxonomic Citation List contains one sublist for each taxonomic field: type of readiness, methodological approach, military service, and military unit. The Author Citation List is in alphabetic sequence by author where all joint authors have been individually entered. The Source Organization Citation List is in alphabetic sequence by source: journal name, university name, government agency, and so on, for all the publishing sources of reference works in the bibliography. The final report on the entire effort is contained in Serial T-455.

Research Supported by

Subcontract SCEEE/AFLMC/80-0001
Air Force Contract F01600-80-D0299

THE GEORGE WASHINGTON UNIVERSITY
School of Engineering and Applied Science
Institute for Management Science and Engineering

Program in Logistics

Abstract
of
Serial T-456
31 December 1981

THE AFLMC BIBLIOGRAPY

by

Zeev Barzily
W. E. Caves
W. H. Marlow
Aswath Rao
Shelemyahu Zacks

The present formal bibliography of 721 references is in alphabetic sequence by first author and year of publication. Taxonomic records are included which classify each reference according to kind of readiness, methodological approach, military service, and military unit. Also included are notes records which list sources of additional information, and library records which furnish document numbers and information on copies in the Air Force Logistics Management Center (AFLMC) collection. The final report on the entire effort is contained in Serial T-455.

Research Supported by

Subcontract SCEEE/AFLMC/80-0001
Air Force Contract F01600-80-D0299

THE GEORGE WASHINGTON UNIVERSITY
School of Engineering and Applied Science
Institute for Management Science and Engineering

Program in Logistics

Abstract
of
Serial T-455
31 December 1981

FINAL REPORT ON THE AFLMC BIBLIOGRAPHY

by

Zeev Barzily
W. E. Caves
W. H. Marlow
Aswath Rao
Shelemyahu Zacks

The Air Force Logistics Management Center (AFLMC) Bibliography contains 721 references on logistics capability and readiness assessment, all of which are classified according to a four-way taxonomy: kind of readiness, methodological approach, military service, and type of military unit. The present report describes the bibliography and its uses based on the taxonomy, special keywords, and certain other features such as entries for joint authors, source organization, Defense Logistics Studies Information Exchange identification numbers, and so on.

Research Supported by

Subcontract SCEEE/AFLMC/80-0001
Air Force Contract F01600-80-D0299

Units A, B and C were the only ones receiving an efficiency rating of one. Note that unit G which had the highest number of "fix" sorties and the second highest number of "non-break" sorties achieved only an efficiency rating of 3.5. It failed to achieve a high enough mission capable maintenance output considering the magnitude of its inputs. In other words, because unit G aircraft break less and can be fixed more quickly in comparison with other units, one would expect unit G to obtain a higher number of mission capable maintenance aircraft-days.

Figure 1 shows the efficiency comparison graphically where inputs have been scaled down so each input combination produces one unit of output. Note that units A, B and C are located on an efficiency "frontier," meaning that no other units produce a unit of output with smaller input combinations.

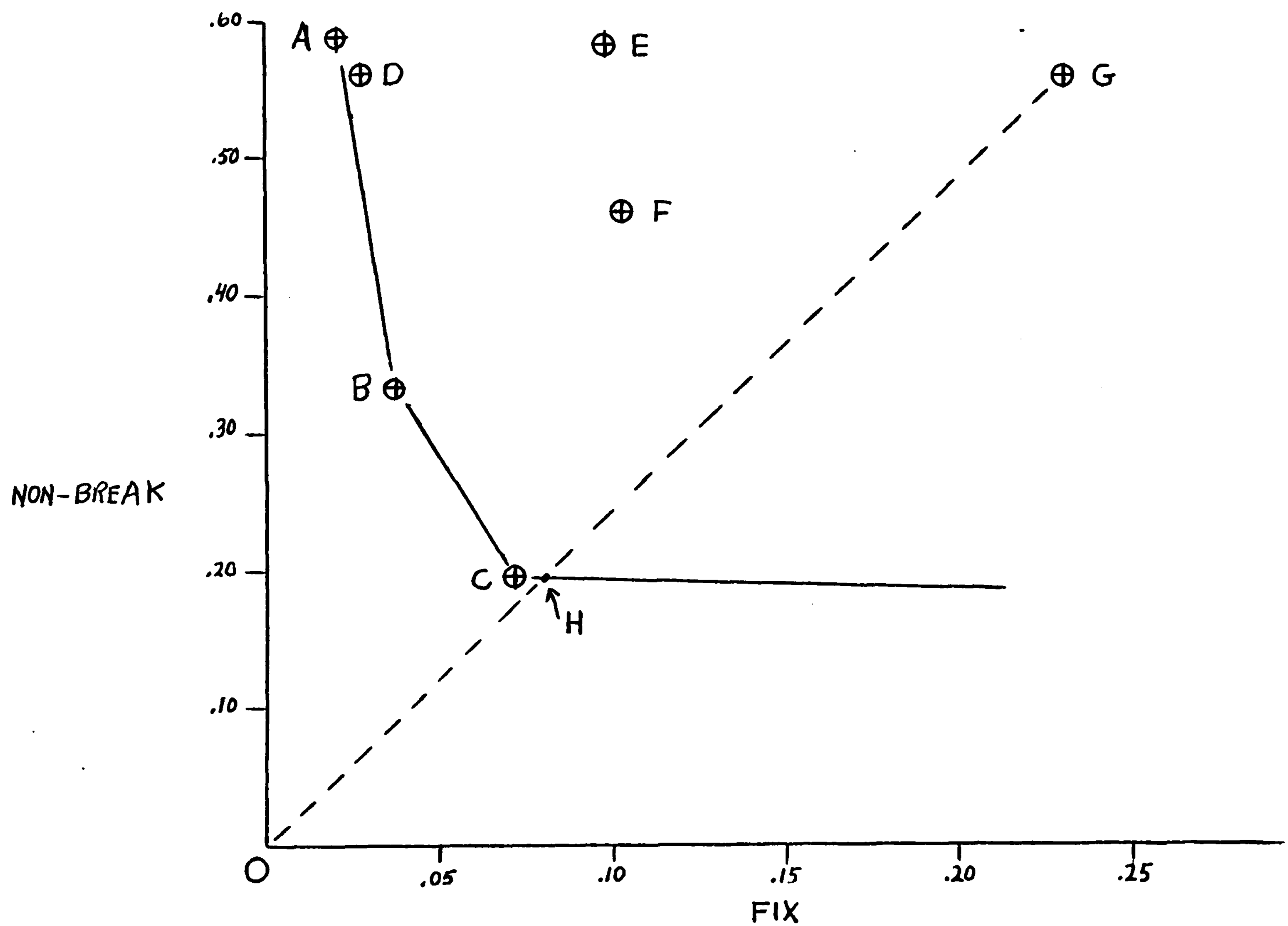


FIGURE 1 : ISOQUANT REPRESENTATION

For this single-output, two-input case, the efficiency measure, h_o, can be computed by dividing the length of the ray from the origin to a unit's coordinate point into the length along that ray from the origin to the frontier. For example, the distance from the origin to the frontier along the ray to unit G is about .2115 (see dotted line segment $\overline{OH}$ in Figure 1), and the distance from the origin to the coordinates at G is about .6042 (length of $\overline{OG}$); thus, the efficiency rating of G = (.2115) $\div$ (.6042) = .350, which matches the value of h_o in Table 1. For evaluations involving multiple outputs ($\geq$ 2) and multiple inputs ($\geq$2), the analysis cannot be accomplished graphically and the use of a computer becomes extremely important, particularly when the number of units is large.

One might ask, is unit G "really" that inefficient? Perhaps G, a training unit, places greater emphasis on sorties than on mission capable maintenance status. To test this possibility, the actual sorties flown by the units during the year were added as an additional output and the analysis reaccomplished. The efficiency rating for units A, B, C, and D remained unchanged; the ratings for E and F improved about 25%; and the rating for G improved drastically from .35 to .95, from the lowest to the second highest rating, implying that perhaps sorties should be included when training organizations are compared to operation units.

Any analysis, including DEA, will produce misleading results if important parameters are overlooked. But DEA can detect "apparent" inefficiencies, and then follow-up DFA evaluations can be conducted to test the sensitivity of the measures to the addition or deletion of variables. It can also provide information on the under utilization of inputs and the magnitude of output deficiencies; moreover, the "multipliers" can be used to evaluate the impact of alternative input and output combinations on efficiency. The article by A. Bessent and E. Bessent [2] contains examples of how these capabilities can be exploited to gain additional insights. Such evidence and sensitivity information in the hands of knowledgeable and experienced managers could very well lead to worthwhile inquires, explanations, and management action. This appears to be the case in Texas schools which have been using the DEA technique for more than a year. Since implementation, nearly all of the schools involved have noted an overall increase in both efficiency and output.

The Air Force would surely benefit from any analytical technique which leads to gains in efficiency and capability. The next section addresses the desired connection between efficiency analysis and management.

5. DECISION SUPPORT

Any model designed to evaluate unit efficiency must be judged in terms of its usefulness to commanders and managers. The managerial activities or monitoring operations, sensing problems, diagnosing causes, and correcting deficiencies must rely on information and analysis of current efficiency problems and causes, and should carefully consider the possible impact of corrective decisions on future efficiency. As a result, efficiency evaluations and decisions require access to timely and pertinent management information during all phases of the decision making process from problem identification to solution.

In recent years, a new approach to designing management information systems has emerged. This approach implies the use of Decision Support Systems (DSS) which focus on using computers to complement the judgement of managers. Computers have been used by the Air Force for many years with substantial success, particularly in the areas of financial and supply accounting. These early systems provided greater efficiency in tracking transactions, recordkeeping, file maintenance and data flow. Large amounts of computer data were made available and numerous retrieval programs were written to provide information to managers. In cases where routine, highly structured management information requirements could be completely specified by managers, data automation personnel developed application programs to retrieve reports tailored to the managers specific needs.

Unfortunately, many important management deisions which require efficiency considerations are complex and semi-structured (or unstructured) causing information requirements to vary with each new situation. Because of the lead times and costs in modifying existing application programs or developing new ones, managers are seldom able to rely on transactional systems in handling semi-structured decision processes. The DSS approach views the role of the computer as a supporting tool which interacts with analysts or managers to improve the effectiveness of their management decisions in accomplishing semi-structured tasks. The remainder of this section will present one area where the DSS approach is warranted, efficiency analysis and management.

The basic question is, how can the Air Force insure that combat resources are invested wisely on those problems or opportunities which will significantly contribute to improving military capability? The hypothesis is that a semi-structured decision support approach to the analysis and management of efficiency would improve the quality of judgement and decisions, establish a more systematic decision process, and increase managerial understanding and control of operations.

Decision Analysis. Russell L. Ackoff of the University of Pennsylvania wrote..."Each (or at least each important) type of managerial decision required by the organization under study should be identified and the relationships between them should be determined"...[1] Decision analysis is one of the key elements of the DSS predesign cycle presented by Keen and Morton [5]. It is the initial stage of design and focuses on describing the decision process, identifying the key decision types, defining normative models, comparing normative and descriptive models and selecting areas for support. The discussion in this paper will be limited to some preliminary ideas about an efficiency-oriented decision process. The concepts presented here will provide a basis for guiding future in-depth decision analyses. The total design problem will undoubtedly require several iterations of change, expansion and refinement until the decision support problem for efficiency evaluations is accurately depicted.

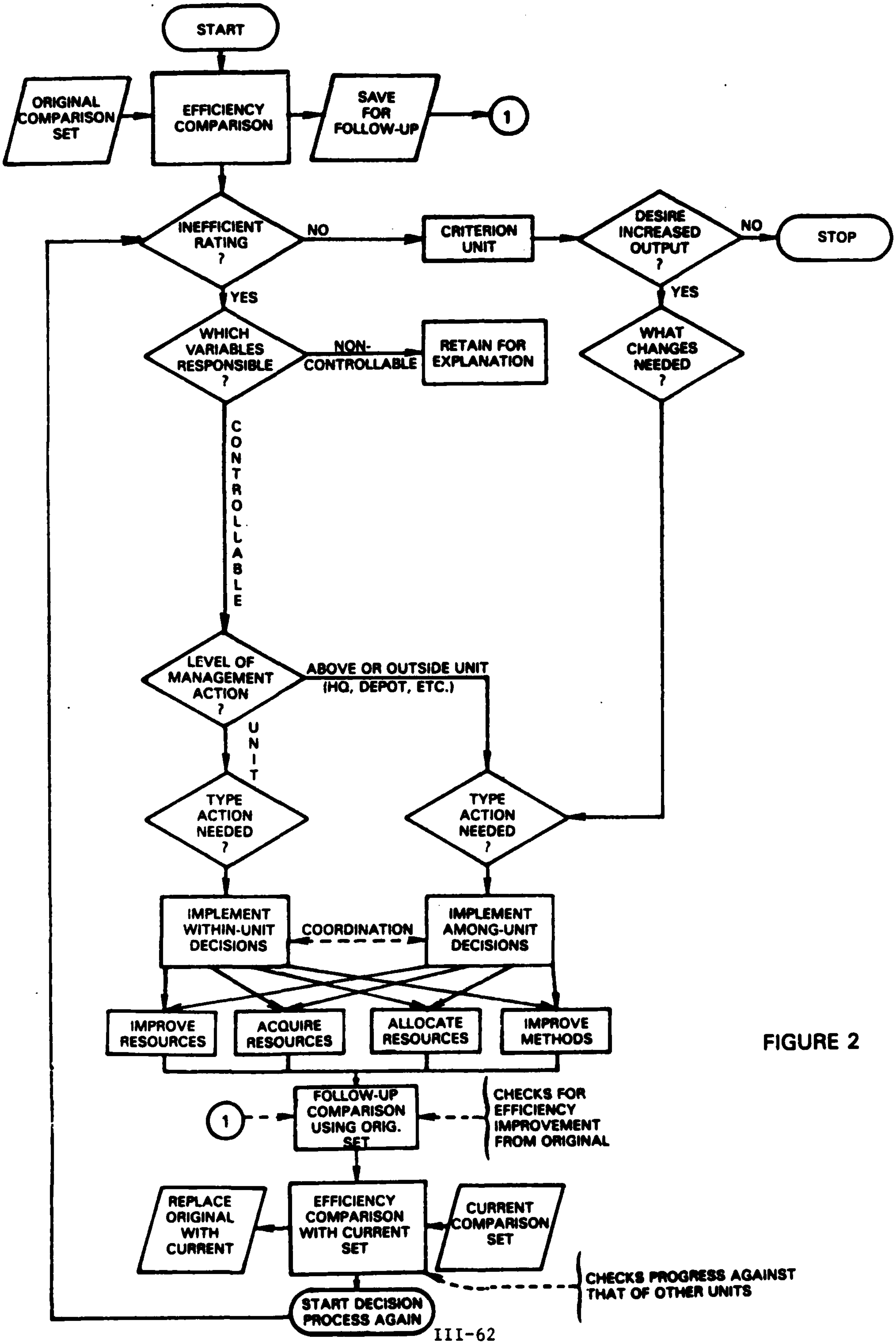

START
ORIGINAL COMPARISON SET
EFFICIENCY COMPARISON
SAVE FOR FOLLOW-UP
1
INEFFICIENT RATING ?
NO
CRITERION UNIT
DESIRE INCREASED OUTPUT ?
NO
STOP
YES
YES
WHICH VARIABLES RESPONSIBLE ?
NON-CONTROLLABLE
RETAIN FOR EXPLANATION
WHAT CHANGES NEEDED ?
CONTROLLABLE
LEVEL OF MANAGEMENT ACTION ?
ABOVE OR OUTSIDE UNIT (HQ, DEPOT, ETC.)
UNIT
TYPE ACTION NEEDED ?
TYPE ACTION NEEDED ?
IMPLEMENT WITHIN-UNIT DECISIONS
COORDINATION
IMPLEMENT AMONG-UNIT DECISIONS
IMPROVE RESOURCES
ACQUIRE RESOURCES
ALLOCATE RESOURCES
IMPROVE METHODS
1
FOLLOW-UP COMPARISON USING ORIG. SET
CHECKS FOR EFFICIENCY IMPROVEMENT FROM ORIGINAL
REPLACE ORIGINAL WITH CURRENT
EFFICIENCY COMPARISON WITH CURRENT SET
CURRENT COMPARISON SET
CHECKS PROGRESS AGAINST THAT OF OTHER UNITS
START DECISION PROCESS AGAIN

FIGURE 2

Efficiency Analysis and Management Action. Figure 2 shows a typical series of steps through which managers monitor and control the efficiency of their organizational units. These steps correspond to the following set of key, recurring management questions.

a. Is the unit efficient when compared to others having similar missions and technologies?

b. If the unit is rated inefficient, which variables are responsible for the low rating? Are there overages in inputs, shortfalls in outputs, or combinations of both? Is a shortage in one input variable limiting the employment of others thereby causing overages?

c. If rated efficient, and if an incrase in outputs is desirable, which inputs can be increased to cause greater output?

d. To what extent are the desired changes in variables controllable by management? For example, weather and other external causes which might reduce efficiency are not controllable. However, these causes and their impacts on efficiency must be identified. Decision making units should not be blamed for sub-standard performance caused by variables beyond their control.

e. If variables are completely or partially controllable, which responsibility center(s) must be involved in taking the appropriate corrective actions?

f. What action(s) is(are) appropriate? Some problems are caused by operational or resource deficiencies which are strictly within the management control of the unit itself. Others are caused by improper support from other agencies upon which the unit must rely, and some problems require a complicated set of managerial interactions among different agencies at different organizational levels. There is a risk of taking the improper management action if errors are made in the efficiency analysis or problem diagnosis. Each manager would want a high degree of assurance that suggested changes are desirable and that these changes will maximize the overall output from sub-units. Assurances are not easy to obtain, but changes will be made nonetheless based on the best available information, Management actions typically fall within one of the following general decision categories:

   1) improve existing resources (manpower, equipment, supplies, facilities, information)

   2) Acquire additional resources

   3) Allocate/reallocate resources (budgets)

   4) Improve production methods (plans, schedules, reorganizations, policies, procedures, etc.)

g. Have the management actions resulted in the desired efficiency changes? A follow-up efficiency evaluation would be useful after corrective actions have had sufficient time to take effect. This evaluation should compare the unit's efficiency to the original comparison set (paragraph a above).

h) Is the unit efficient when compared to current data from other units in the comparison set? This would measure progress made versus that achieved by others, and it begins the cycle again.

Each of the above questions is a significant problem within itself. Data envelopment analysis can provide some of the answers. It can identify inefficient units, provide limited information on possible causes, and might be of some help in deciding among alternative management actions. But feasible solutions to these complex problems cannot be easily obtained unless sound analytical methods are supplemented by the judgement and experience of key managers at appropriate times during the decision process. Further development and testing of DEA together with related modeling efforts should produce a DSS which will provide much improved analytical support in diagnosing problems and generating alternative solutions. The DSS will not replace experienced managers; but through the use of computer technology it can provide access to powerful analytical models capable of rapidly responding to inquiries and "what if" questions of managers.

To be truly responsive to decision makers, a DSS must be designed so that analyses can be done at any time by anyone needing the information. This suggests that the DSS should be a "user friendly" interactive system as shown in Figure 3. DEA already has interactive capability, but further work is required in expanding DEA theory and software so a system is built which is suitable for use by Air Force units. The following related study activities are also suggested to enhance the development of DEA as a decision support tool:

a. Determine the feasibility of using DEA to assess the influence of different budget levels on combat sortie generation. If the relative efficiency of each unit is known, what is the possibility of using the results of efficient units to predict output levels (assuming efficient utilization) associated with varying levels of inputs (budgets).

b. Analyze problems of measurement and the selection of inputs and outputs. Develop rules of measurement and selection which improve the validity of the analysis results. Threats to validity resulting from dependence among input variables (e.g., using two

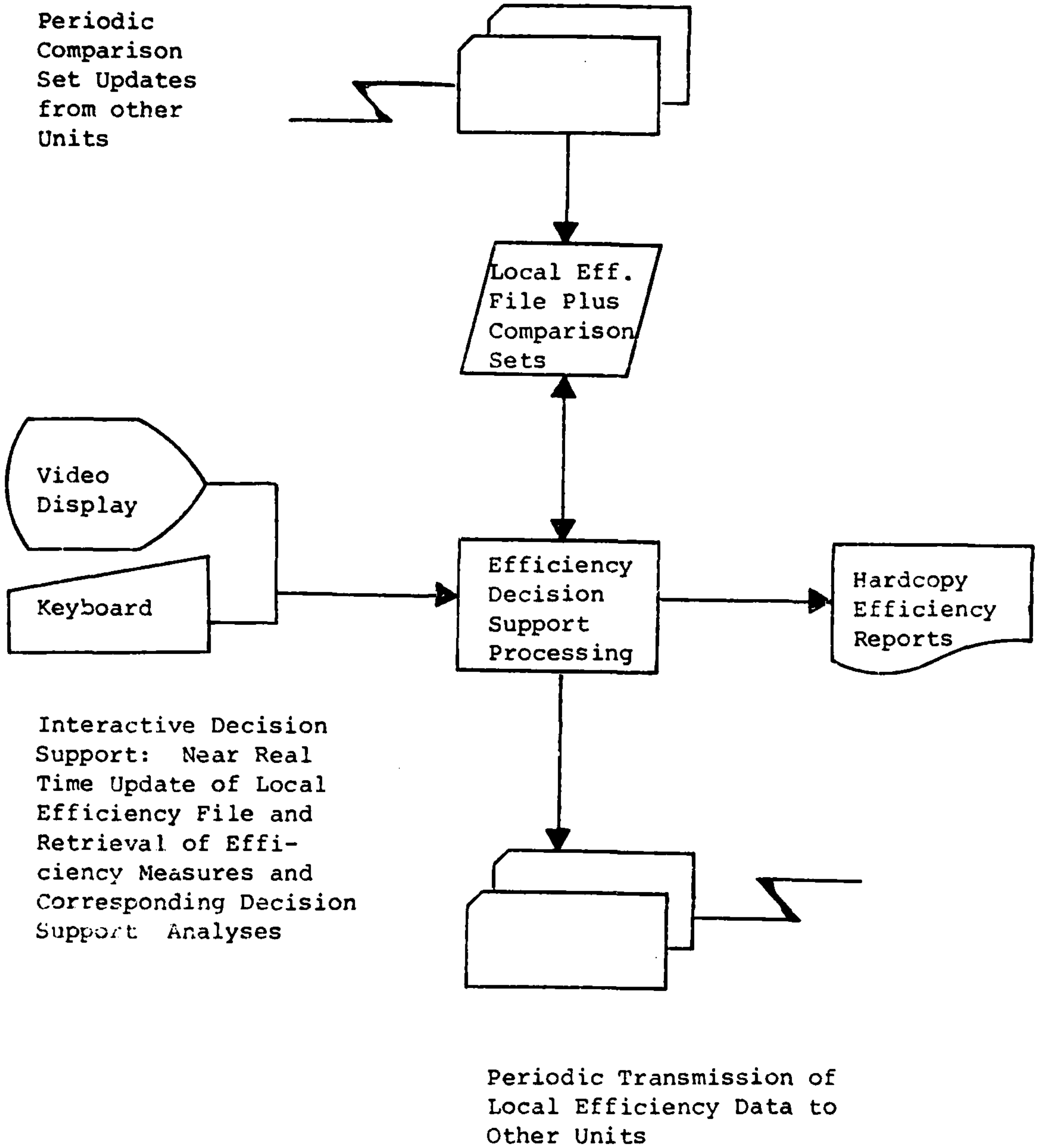

Periodic Comparison Set Updates from other Units
Local Eff. File Plus Comparison Sets
Video Display
Keyboard
Efficiency Decision Support Processing
Hardcopy Efficiency Reports
Interactive Decision Support: Near Real Time Update of Local Efficiency File and Retrieval of Efficiency Measures and Corresponding Decision Support Analyses
Periodic Transmission of Local Efficiency Data to Other Units

Figure 3.

different measures of the same factor), from the use of inputs which are surrogate variables or production correlates, and from the absence of causal evidence...all should be thoroughly investigated and documented.

c. Further refine the distinctions between the terms technical efficiency and develop a theory for evaluation of one type of efficiency when the other has been stipulated. For example, the Air Force might wish to evaluate the difference between two aircraft maintenance organizational concepts under stipulated technologies.

d. Develop a model and associated efficient algorithms to support decisions of resource sharing and allocation. This includes questions of where to allocate inputs, how much (if any) should be withdrawn from which units, and how to take into account all the bounds and constraints which limit the solution alternatives.

6. CONCLUSION

The Air Force unquestionably needs to monitor and manage the efficiency and capability of combat units. But efficiency information and analysis must not be based on "partial" measures which can lead to erroneous decisions and ill-advised managerial actions. The Data Envelopment Analysis and Decision Support concepts presented in this paper appear to have considerable potential for application to the multi-input, multi-output efficiency assessment problems of the Air Force.

Four of the desired outcomes of the DEA decision support development are:

1) to improve the decision making effectiveness of commanders and resource managers;

2) to make inefficiencies more visible to decision makers;

3) to provide evidence which suggests needed changes to policies, budgets, organizations or resources; and

4) to supply pressure or incentive to improve technical factors and increase combat efficiency.

The benefit from achievement of these goals is obvious.

REFERENCES

[1] Ackoff, Russell A., "Management Misinformation Systems," (Management Science, Vol. 14, No. 4, December, 1967), p. 20.

[2] Bessent, A., and Bessent, E. W., "Determining the Comparative Efficiency of Schools Through Data Envelopment Analysis," (Education Administration Quarterly, Vol. 16, No. 2, Spring 1980), pp 57-75.

[3] Charnes, A., Cooper, W. W. and Rhodes, E., "Measuring the Efficiency of Decision Making Units" (European Journal of Operational Research, Vol. 2, No. 6, November 1978), pp. 429-444.

[4] "Efficiency," Encyclopedia of the Social Sciences, 5:437.

[5] Keen, P. G. and Scott Morton, M.S., Decision Support Systems: An Organizational Perspective, Addison-Wesley Series on Decision Support, Addison-Wesley Publishing Company, 1978.

PRESENTED BY MR. JOHN GREENE, HQ TAC/LGXS.

SLIDE L1

TALI - THIS IS AN INFORMATIONAL BRIEFING ON TALI, TACTICAL ANALYSSIS LOGISTICS INFORMATION SYSTEM.

SLIDE L2

OVERVIEW - THE BRIEFING WILL BE STRUCTURED IN THIS FORMAT, TO COVER TAC'S PAST EFFORTS IN TALI, THE SYSTEM CAPABILITIES, AND WHERE WE ARE GOING.

SLIDE L3

PURPOSE - TALI IS A TAC-DEVELOPED AUTOMATED SYSTEM THAT PROVIDES THE FIRST CONSOLIDATED WAR CONSUMABLES DATA BASE FOR VISIBILITY ON WORLDWIDE ASSETS. IT WAS DEVELOPED BECAUSE THE MANUAL PROCESS OF COLLECTING AND COMPUTING WAR CONSUMABLE INFORMATION (ON SUCH ITEMS, MUNITIONS, TANKS, RACKS, PYLONS, ETC.) REQUIRED FOR SPECIFIC WARTIME SCENARIOS WAS NOT RESPONSIVE. IN TIME SENSITIVE SITUATIONS, TALI IS A VALUABLE TOOL IN RAPIDLY COMPUTING NEEDED INFORMATION FOR REALISTIC LOGICAL DECISIONS ON HOW TO SUPPORT WARTIME SCENARIOS.

SLIDE L4

OBJECTIVES - THE MAIN OBJECTIVES OF TALI WERE TO ALLOW US TO DETERMINE THE LOGISTIC SUPPORT REQUIRMENTS FOR A GIVEN FORCE, IN A GIVEN THEATER, BY PLANNED OPERATING BASE, FOR A MEASURABLE TIME FRAME, AT CHANGING SORTIE RATES, AND MEASURE THE SUPPORTABILITY IN TERMS OF SORTIES AND DAYS.

ALLOW US TO DETERMINE MONETARY COSTS OF REQUIREMENTS FOR CONTINGENCY PLANNING, BEDDOWN AND SORTIE SURGE RATES BASED ON CHANGING

REQUIREMENTS.

ALSO, ALLOW US TO DEVELOP AND PRODUCE THE WAR CONSUMABLE DISTRIBUTION OBJECTIVE (WCDO) BASED ON DATA CONTAINED IN THE WAR AND MOBILIZATION PLAN VOLUME 4 (WMP 4) AND CONSUMPTION DATA PROVIDED BY THE MAJOR COMMANDS.

SLIDE L5

PRESENT - TALI IS ON LINE AND ACCESSIBLE AT HEADQUARTERS USAF, TAC, USAFE, PACAF AND TAC'S NUMBERED AIR FORCES AND BASES.

SLIDE L6

THE BIGGEST DAY TO DAY BENEFIT OF TALI IS IT ALLOWS PREPARATION OF WCDO'S FOR EACH PLANNED OPERATING BASE. THIS IS A MAJOR TASK IN TAC BECAUSE OF RDF FORCES, ADTAC AND TAC-GAINED AIR NATIONAL GUARD UNITS AS WELL AS USAFE AND PACAF, WHERE THERE ARE SIGNIFICANT PREPOSITIONED RESOURCES.

SLIDE R1

LET'S NOW LOOK AT THE RESULTS OF A WCDO BEING COMPUTED AT THE MAJOR COMMAND LEVEL IN LIEU OF AFLC. THE TIME SAVINGS IS 113 DAYS. THE BIG DIFFERENCE BEING,

OLD METHOD		NEW METHOD
WAA TAPE TO AFLC BY COURIER	VS	WAA TAPE TO MAJCOM BY WIN
METHOD AFLC USES TO PRODUCE WCDO	VS	TALI PRODUCE WCDO
AFLC DISTRIBUTION OF WCDO TO MAJCOM	VS	NO TIME INVOLVED AS WCDO PRODUCE AT MAJCOM

MAJCOM EDIT REQUIRED TO COMPARE MAJCOM EXPENDITURE PER SORTIE FACTOR (EPSF), WITH WCDO PRODUCE BY AFLC	VS	EPSF REVIEWED BY MAJCOM PRIOR TO WCDO BEING COMPUTED

SLIDE R2

NEXT, WE LOOK AT THE TALI-COMPUTED WCDO OUTPUT PRODUCT. ONE OF THE MAJOR CHANGES IS THE REQUIREMENTS BEING COMPUTED AND REFLECTED IN THE SAME TIME PERIODS AS DOCUMENTED IN THE WMP-4. EXAMPLE: PERIOD 1-5, 6-10, 11-15, 16-20, ETC. IN LIEU OF THE AFLC METHOD OF ONLY THREE TIME PERIODS, WHICH REFLECTED REQUIREMENTS FOR 1-30, 31-60 AND 61-90 DAYS TOTALS. THE TALI WCDO PROVIDES VISIBILITY ON MUNITIONS AND TANK BUILD-UP REQIREMENTS. ALSO, REQUIREMENTS TO SUPPORT A SORTIE SURGE COULD BE REFLECTED.

SLIDE L7

<u>WORLDWIDE ASSET VISIBILITY</u> - THE TALI SYSTEM PROVIDES VISIBILITY OF WRM ASSETS WORLDWIDE. THE OUTPUT PRODUCT IS BASED ON THE DESIRED SELECTION OF DATA.

SLIDE R3

<u>VISIBILITY OF ASSETS BY THEATER</u> - HERE IS AN EXAMPLE OF ASSETS PREPOSITIONED BY THEATER, WHICH IN REALITY WOULD BE FOR USAFE, PACAF, CONUS, ETC. THE OUTPUT PRODUCT WOULD REVEAL THE FOLLOWING INFORMATION:

- LOCATION
- LOGISTICAL AREA
- NOMENCLATURE
- QUANTITY

WCDO DATA FLOW/TIMING

OLD METHOD		NEW METHOD
X DAY	WAA (TAPE)	X DAY
15 DAYS	AFLC/MAJCOM	5 DAYS
90 DAYS	PRODUCE WCDO	10 DAYS
10 DAYS	DISTRIBUTION TO MAJCOM	0 DAYS
15 DAYS	MAJCOM EDIT	5 DAYS
8 DAYS	DISTRIBUTION TO REPORTING	5 DAYS
	PLANNED OPERATING BASE	
138 DAYS		25 DAYS

LG 4221

PRESENT

- ON-LINE AND ACCESSIBLE
- *** WAR CONSUMABLES DISTRIBUTION OBJECTIVE (WCDO) COMPUTED AT MAJCOM
- WORLDWIDE ASSET VISIBILITY
- REQUIREMENTS/CAPABILITY TO SUPPORT APPROVED WAR PLANS

LG 4209a

PRESENT

- *** ON-LINE AND ACCESSIBLE
- WAR CONSUMABLES DISTRIBUTION OBJECTIVE (WCDO) COMPUTED AT MAJCOM
- WORLDWIDE ASSET VISIBILITY
- REQUIREMENTS/CAPABILITY TO SUPPORT APPROVED WAR PLANS

LG 4209

OBJECTIVES

- DETERMINE SUPPORT REQUIREMENTS/CAPABILITY
- MONETARY COSTS OF REQUIREMENTS
- PRODUCE WAR CONSUMABLE DISTRIBUTION OBJECTIVE (WCDO)

LG 4208

PURPOSE

PROVIDE LOGISTICS STAFF WITH
VISIBILITY ON CRITICAL LOGISTICS
INFORMATION AND TIME SENSITIVE DATA

LG 4207

OVERVIEW

- PURPOSE
- OBJECTIVES
- PRESENT
- FUTURE
- SUMMARY

LG 4206

DIRECTORATE OF LOGISTIC PLANS

TACTICAL

ANALYSIS

LOGISTICS

INFORMATION

SYSTEM

LG 4205

SLIDE L14

IM SUMMARY, TALI IS THE FIRST SYSTEM TO PROVIDE A CONSOLIDATED DATA BASE FOR WAR CONSUMABLES (NO SPARES) ANALYSIS, HAS MAJCOMS' PLANNING FACTORS (SCL'S, EPSF'S) AND USES STANDARD ASSETS REPORTS TO KEEP THE DATA BASE UPDATED. SYSTEM UTILITY FOR ACTUAL WAR-TIME MANAGEMENT OR PEACETIME PLANNING "WHAT-IF" IS UNLIMITED AT THIS TIME, IT CONTINUES TO BE THE MOST ADVANCED COMPUTER PROGRAM IN THE AIR FORCE FOR MANAGEMENT OF WAR CONSUMABLES AND IDENTIFYING POTENTIAL PROBLEMS THAT AFFECT THE SUPPORTABILITY OF COMBAT FORCES. UPON ENHANCEMENT AND DEVELOPMENT/RELEASE AS LOGFAC, THE LOGISTICS COMMUNITY WILL HAVE THE MOST POWERFUL CONTINGENCY MANAGEMENT SYSTEM EVER.

ITEM IDENTIFY FILE (OTHER CONSUMABLES), AND THE COMMAND EQUIPMENT MANAGEMENT RECORDS (EQUIPMENT).

* WAA/WARCONFAC MATCH (300 HOURS) - WILL COMPARE THE WMP-4 LINES OF ACTIVITY WITH THE EXPENDITURE PER SORTIE FACTORS TO INSURE FACTORS ARE AVAILABLE PRIOR TO COMPUTING A WCDO.
* WHOLE ROUND MODIFICATION (107 HOURS) - IMPROVES THE FLEXIBILITY IN DISPLAYING COMPLETE ROUNDS OF MUNITIONS.
* TARGET/TRANSPORTATION MODULE (1023 HOURS) - TARGET MODULE WILL PROVIDE THE CAPABILITY TO COMPUTE THE REQUIREMENTS AND THEN COMPARE THE ON HAND ASSETS TO SUPPRESS SELECTED TARGETS. TRANSPORTATION MODULE WILL PROVIDE THE METHOD OF TRANSPORTATION COST OF MOVEMENT IN SUPPORT OF CURRENT AND OUT YEAR REQUIREMENTS.
* D078, CSMS, CFMS, WAA ON LINE INTERFACE (1778 HOURS) - WILL PROVIDE AN AUTOMATED INTERFACE WITH MUNITIONS (D078), THE COMMAND SUPPLY MANAGEMENT (CSMS) AND THE COMMAND FUELS MANAGEMENT (CFMS) SYSTEMS.

  INTERFACE WITH THE CSMS AND CFMS SYSTEMS IS OF GREAT IMPORTANCE AS IT WILL PROVIDE DAILY UPDATES OF PEACETIME AND WRM ASSETS. ENHANCEMENTS TO THE CSMS AND CFMS SYSTEM COULD ELIMINATE MANY MANUAL PREPARED REPORTS. INTERFACE WITH THE WARTIME AIRCRAFT ACTIVITIES FILES WILL ELIMINATE DUPLICATE WARTIME LINES OF ACTIVITY.
* OTHER ENHANCEMENTS INCLUDE TPFDL INTERFACE, OUTPUTS IN OPLAN FORMATS AND A LOGREQ/FORSIZE CAPABILITY.

* CUBE AND WEIGHT OF PREDIRECT QUANTITY
* NUMBER OF SORTIES ON HAND QUANTITY WILL SUPPORT
* NUMBER OF SORTIES PREDIRECT QUANTITY WILL SUPPORT
* TOTAL NUMBER OF DAYS ON HAND AND PREDIRECT QUANTITIES

SLIDE L13

FUTURE ENHANCEMENTS - TALI IS TO BECOME A STANDARD AIR FORCE SYSTEM.

TALI WILL BE A SUBSYSTEM UNDER THE CONTINGENCY OPERATION MOBILITY PLANNING AND EXECUTION SYSTEM (COMPES).

THE NAME TALI WILL BE CHANGED TO LOGFAC (LOGISTICS FEASIBILITY ANALYSIS CAPABILITY).

LOGFAC WILL BE MAINTAINED AND CONTINUED IN DEVELOPMENT BY TAC.

WE ARE CURRENTLY WORKING WITH THE AIR STAFF, AIR FORCE LOGISTICS MANAGEMENT CENTER (AFLMC) AND AIR FORCE DATA SYSTEM DESIGN CENTER (AFDSDC) ON A DRAFT DATA PROJECT DIRECTIVE (DPD) WHICH WILL DEFINE EACH AGENCY'S RESPONSIBILITY.

LISTED HERE ARE SOME OF THE CURRENT PLANNED FUTURE ENHANCEMENTS.

* <u>STAMP PACKAGES</u> (340 HOURS) - THE STANDARD AIR MUNITIONS PACKAGES WILL PROVIDE THE CAPABILITY TO EXTRACT INFORMATION ON DEPOT AND PACER FLEX ASSETS CONTAINED IN THE STAMP PACKAGES.
* <u>WCDO TONNAGE</u> (550 HOURS) - REFLECT SHORT TONS IN THE MAJOR COMMAND PRODUCE WAR CONSUMABLE DISTRIBUTION OBJECTIVE.
* <u>WHAT-IF EPSF'S</u> (515 HOURS) - WILL PROVIDE THE CAPABILITY TO USE MULTIPLE EXPENDITURE PER SORTIE FACTORS IN WHAT-IF ANALYSIS.
* <u>AUTOMATED UPDATE OF RIF, IIC, XREF, CEMO</u> (515 HOURS) - PROVIDE AUTOMATED UPDATES OF THE REPORTABLE ITEM FILE (MUNITIONS), THE

- QUANTITY REQUIRED
- UNIT OF ISSUE
- CUBE AND WEIGHT
- DAYS OF SUPPORT AVAILABLE AT PLANNED OPERATING BASE

SLIDE R10

SUPPORT WHAT-IF SCENARIOS - SIMPLY BY CHANGING THE SELECTION DESIRED FROM SORTIE RATE TO SORTIES, LET'S NOW LOOK AT THE SUPPORT IN TERMS OF SORTIES THAT COULD BE SUPPORTED. THE WHAT-IF SCENARIO MODEL CAN AND HAS BEEN USED IN POM DEVELOPMENT.

SLIDES L12 AND R11

LET'S NOW LOOK AT A TOTAL CAPABILITY PICTURE FOR AN ACTUAL WAR PLAN OR A WHAT-IF SCENARIO. THE FOLLOWING INFORMATION IS REFLECTED:

- PLANNED OPERATING BASE
- NUMBER AND TYPE OF AIRCRAFT
- SORTIE RATE
- ROLE OR SCL
- % SORTIE EFFECTIVE
- NUMBER OF SORTIES
- NOMENCLATURE
- QUANTITY REQUIRED
- QUANTITY ON HAND
- QUANTITY PREDIRECT
- QUANTITY SHORT
- UNIT OF ISSUE

- CUBE AND WEIGHT
- NUMBER OF DAYS WHICH CAN BE SUPPORTED

SLIDE L9

PRESENT WHAT-IF SCENARIOS - ANOTHER IMPORTANT PART OF LOGISTICS IS BEING ABLE TO REACT TO THE WHAT-IF'S IN PEACETIME AS WELL AS WARTIME. THE ABILITY TO IDENTIFY THE REQUIREMENTS, COST AND SUPPORT OF REQUIREMENTS IS OF GREAT SIGNIFICANCE AND CANNOT BE OVER-STRESSED.

SLIDE L10
SLIDE R8

REQUIREMENTS/COST OF WHAT-IF SCENARIOS - LET'S NOW LOOK AT THE REQIREMENTS/COST FOR A WHAT-IF SCENARIO. USING 24 F4E AIRCRAFT AT 2.0 SORTIE RATE FOR 5 DAYS IN A SPECIAL CONTINGENCY ROLE, THE REQUIREMENTS AND COST WOULD BE AS REFLECTED WITH A TOTAL COST OF $5,741,709.00.

SLIDE L11
SLIDE R9

SUPPORT WHAT-IF SCENARIOS - NEXT, WE LOOK AT THE SUPPORT CAPABILITY WHEN THE INPUT IS DEFINED IN A SORTIE RATE. INFORMATION REFLECTED IS AS FOLLOWS:

- PLANNED OPERATING BASE
- NUMBER AND TYPE OF AIRCRAFT
- NUMBER OF DAYS FOR SPECIFIC FORCE
- SORTIE RATE
- ROLE
- SORTIES
- NOMENCLATURE

SLIDE R6

LET'S NOW LOOK AT THE OUTPUT PRODUCT PRODUCED TO IDENTIFY THE REQUIREMENTS FOR A SPECIFIC WAR PLAN. THE PRODUCT REFLECTS THE FOLLOWING:

- TYPE AND NUMBER OF AIRCRAFT
- AIRCRAFT ROLE
- NUMBER OF SORTIES
- PLAN
- NOMENCLATURE
- QUANTITY REQUIRED
- UNIT OF ISSUE
- CUBE
- WEIGHT
- COST BY END ITEM
- TOTAL COST TO SUPPORT APPROVED FORCE

SLIDE R7

NEXT, WE LOOK AT THE CAPABILITY TO SUPPORT THAT WAR PLAN. THE OUTPUT GENERATED WOULD REFLECT THE FOLLOWING:

- PLANNED OPERATING BASE
- TYPE AND NUMBER OF AIRCRAFT
- NUMBER OF DAYS
- AIRCRAFT ROLE
- NUMBER OF SORTIES
- PLAN
- NOMENCLATURE
- QUANTITY REQUIRED
- UNIT OF ISSUE

- UNIT OF ISSUE
- CUBE
- WEIGHT
- STORAGE LOCATION

WHERE THE CUBE AND WEIGHT IS BLANK, AFLC HAS NOT PROVIDED THIS INFORMATION.

SLIDE R4

<u>VISIBILITY OF ASSETS BY NUMBERED AIR FORCE</u> - THE OUTPUT PRODUCT REFLECTED HERE REVEALS ASSET VISIBILITY BY NUMBERED AIR FORCE. INFORMATION REVEALED WOULD BE THE SAME AS THE PREVIOUS SLIDE, EXCEPT ASSETS REFLECTED WOULD BE FOR THOSE PLANNED OPERATING BASE WITHIN THE OPERATIONAL CONTROL OF THE SELECTED NUMBERED AIR FORCE.

SLIDE R5

<u>VISIBILITY OF ASSETS BY PLANNED OPERATING BASE</u> - THE OUTPUT PRODUCT REFLECTED HERE IS OF GREAT IMPORTANCE AS IT PROVIDES THE ASSETS ON HAND AT A PLANNED OPERATING BASE, BUT ALSO INDICATES UNDER THE PREDIRECT COLUMN THE QUANTITY WHICH IS STORED AT ANOTHER LOCATION, BUT IS REQUIRED FOR THIS PLANNED OPERATING BASE. THE CUBE AND WEIGHT ARE FOR THE QUANTITY TO BE PREDIRECTED.

SLIDE L8

<u>REQUIREMENTS/CAPABILITY TO SUPPORT APPROVED WAR PLANS</u> - THE ABILITY TO IDENTIFY REQUIREMENTS AND THE CAPABILITY TO SUPPORT APPROVED WAR PLANS CANNOT BE OVER STATED. IT IS PART OF THE EVERYDAY LIFE OF LOGISTICS.

WCDO

UC	STOCK NUMBER	END ITEM	ITEM CODE	NOMENCLATURE	UI	MDS	ROLE	PC	PERIOD 1-5
0T	1305001823081	A919		CART 20MM HEI M14LKD	MX	F004E	SCN	A	90
0T		BA2R		BOMB MK82-AIRB RET	EA	F004E	SCN	A	456
0T	1325008287478	BA2R	BY52	METAL TAIL PLUG	EA	F004E	SCN	A	465
0T	1325000285817	BA2R	EY21	FERRULE ARMING WIRE	EA	F004E	SCN	A	1140
0T	1325009386984	BA2R	F721	FUZE TAIL FMU54B	EA	F004E	SCN	A	465
0T	1325000285815	BA2R	FW25	CLIP ARMING WIRE	EA	F004E	SCN	A	1395
0T	9505007546177MN	BA2R	FY56	ARMING WIRE SS 063	EA	F004E	SCN	A	6850
0T	1325009381937	BA2R	G382	MK43 SENSING DEVICE	EA	F004E	SCN	A	465

LG 4220

PRESENT

- ON-LINE AND ACCESSIBLE
- WAR CONSUMABLES DISTRIBUTION OBJECTIVE (WCDO) COMPUTED AT MAJCOM
- *** WORLDWIDE ASSET VISIBILITY
- REQUIREMENTS/CAPABILITY TO SUPPORT APPROVED WAR PLANS

LG 4209b

ASSETS BY THEATRE

LOCATION - THEATRE NOUN	QUANTITY	UI	(XXXX) CUBE	WEIGHT	REPORT AREA - XX STORAGE LOCATION
BREECH BOLT GAU 9A	516	EA	14861	258	STORAGE LOCATION
BBL GUN 40MM M2A1	71	EA	3763	57	BLANK TO PRECLUDE
BBL GUN M61	15846	EA	145783	10141	CLASSIFYING SLIDE
BBL GUN GAU-2B-A	83	EA	42	1	
LAUNCHER LAU 88A	1	EA	470	4	
MISSILE AGM 65A	20	EA	15280	84	
MISSILE AIM-4F	479	EA	110170	838	
MISSILE AIM-4DB	112	EA	25760	196	
MISSILE AIM-4G	481	EA	110630	842	
PROPYLENE GLYCOL	440	EA	588	20	
FLUID DEICING&DEFR	527768	GL	705626	24013	
NITROGEN TECH LIQUID	1221	GL	1632	41	

LG 4217

ASSETS BY NUMBERED AIR FORCE

LOCATION - NUMBERED AIR FORCE (XXXX) REPORT AREA - XX

NOUN	QUANTITY	UI	CUBE	WEIGHT	STORAGE LOCATION
7.62MM LK 9/1	1755	MX	21060	702	STORAGE LOCATIONS
7.62MM LK 4/1	407	MX	488	163	BLANK TO PRECLUDE
20MM HEI M14LK	989	MX	189888	4648	CLASSIFYING SLIDE
20MM HEI-HEIT M14LK	24	MX	461	113	
40MM HEI&P PGU9	22	EA	23	1	
105MM HE M1	9948	EA	79266	2551	
CTG 105MM BLANK M395	93	EA	167	24	
ROCKEYE MK20 MOD3	28	EA	9996	70	

LG 4216

ASSETS BY PLAN OPERATING BASE

LOCATION - TIMBUCKTU NOUN	NOR SERVICEABLE	(XXXX) PREDIRECT	UI	CUBE OF PREDIRECT	WEIGHT OF PREDIRECT
7.62MM LK 9/1	19305	23788	MX	285456	9515
ROCKEYE MK20 MOD3	682	899	EA	6542	12367
MISSILE AGM 65A	350	476	EA	7846	88763

LG 4219

PRESENT

- ON-LINE AND ACCESSIBLE
- WAR CONSUMABLES DISTRIBUTION OBJECTIVE (WCDO) COMPUTED AT MAJCOM
- WORLDWIDE ASSET VISIBILITY
- *** REQUIREMENTS/CAPABILITY TO SUPPORT APPROVED WAR PLANS

LG 4209c

REQUIREMENTS

TIMBUCKTU NOR PLAN XXXX

F015AB OAG ROLE 180 SORTIES

NOMENCLATURE	QUANTITY	UI	CUBE	WEIGHT	COST
20MM HEI M14LK	42	MX	8064	197	$301140.000
CART ENG MXU/4A-A	360	EA	1462	22	25326.000
TURB FUEL AVIAN JP4	11229	BL	630463	15563	556509.240
FLUID DEICING&DEFR	2700	GL	3610	123	1836.000
OXYGEN BREATHING LIQ	360	GL	481	17	13.680
MISSILE AIM-7F11	540	EA	36221	972	30493728.000
MISSILE AIM-9L	540	EA	45621	468	7808544.000

TOTAL COST OF FORCE WAS $39,188,333.760

LG 4214

CAPABILITY

TIMBUCKTU NOR PLAN XXXX

24 F015AB 3 DAYS 2.50 RATE OAG ROLE 180 SORTIES

NOMENCLATURE	QUANTITY	UI	CUBE	WEIGHT	DAYS OF SUPPORT
FLUID DEICING&DEFR	2700	GL	3610	123	0
OXYGEN BREATHING LIQ	360	GL	481	17	0

LG 4215

PRESENT

*** ● WHAT-IF SCENARIOS

● REQUIREMENT/COST

● SUPPORT

LG 4213

PRESENT

- WHAT-IF SCENARIOS
- *** REQUIREMENT/COST
- SUPPORT

LG 4213a

REQUIREMENT/COST

TIMBUCKTU NOR

F004E NOMENCLATURE	SCN ROLE QUANTITY	UI	CUBE	240 SORTIES WEIGHT	COST
TURB FUEL AVIAN JP4	16714	BL	938424	23166	$828345.840
FLUID DEICING&DEFR	3600	GL	4813	164	2448.000
OXYGEN BREATHING LIQ	480	GL	642	23	18.240
MER ION O-B/C-L F4	36	EA	9108	39	125208.000
TER 9A F4 ACFT	48	EA	12144	23	47808.000
ADAPTER CTR-L F4	24	EA	2616	15	61608.000
TANK/PLY 370GAL F4	75	EA	205125	181	174600.000
TANK 600 GAL CL F4	11	EA	34705	119	38500.000

TOTAL COST OF FORCE WAS $5,741,709.890

LG 4224

SUPPORT "WHAT-IF" - SORTIE RATE

TIMBUCKTU NOR

24 F004E 5 DAYS 2.00 RATE SCN ROL/SCL 240 SORTIES

NOMENCLATURE	QUANTITY	UI	CUBE	WEIGHT	DAYS OF SUPPORT
DISP FLARE SUU 25C/A	2	EA	210	1	5
FLARE LUU-2A/B	154	EA	2165	19	3
TURB FUEL AVIAN JP4	16714	BL	938424	23166	.5
FLUID DEICING&DEFR	3600	GL	4813	164	.5
OXYGEN BREATHING LIQ	480	GL	642	23	1
MER ION O-B/C-L F4	36	EA	9108	39	5
TER 9A F4 ACFT	48	EA	12144	23	3
ADAPTER CTR-L F4	24	EA	2616	15	3

LG 4211

SUPPORT "WHAT-IF" - SORTIES

TIMBUCKTU NOR
F004E SCN ROLE 240 SORTIES

NOMENCLATURE	QUANTITY	UI	CUBE	WEIGHT	SORTIES SUPPORTED
FLARE LUU-2A/B	154	EA	656	6	177
TURB FUEL AVIAN JP4	16714	BL	938424	23166	26
FLUID DEICING&DEFR	3600	GL	4813	164	42
OXYGEN BREATHING LIQ	480	GL	642.	23	99
MER ION O-B/C-L F4	36	EA	9108	39	240
TER 9A F4 ACFT	48	EA	12144	23	165
ADAPTER CTR-L F4	24	EA	2616	15	165

LG 4212

PRESENT

- WHAT-IF SCENARIOS
- REQUIREMENT/COST
- *** SUPPORT

LG 4213b

REQUIREMENTS

TALI SORTIE CAPABILITY REPORTS

BASE NAME CNTRY 24 F4E MDS

NOMENCLATURE	REQD	QUANTITY ON-HAND	PREDCT	SHORT	UI
20MM HEI M14LK	219	355	127	0	MX
BOMB CHAFF MJU-1	156	0	0	158	EA
DISP/BOMB CBU 528	989	0	1473	0	EA
BOMB MK82 GP HE	108	0	2410	0	EA
BOMB MK82 RETARDED	7327	673	3112	3542	EA
CTG IMP MK2 MOD-1	148	6004	0	0	EA
CTG IMP MK9 MOD-1	261	10454	0	0	EA
CTG IMP ARD 863-1	8562	25381	0	0	EA
CHAFF TYPE RR155-AL	246	696	0	0	RO
CHAFF TYPE RR156	246	694	0	0	RO
CHAFF TYPE RR163	246	600	0	0	RO

LG 4223

SUPPORT - SORTIES/DAYS

2,000 RATE (SHORTAGES ONLY) CUBIC FT	791 SCL SHORT TONS	100% SORTIE CAPABILITY ON-HAND	PREDCT	1440 SORTIE DAYS SUPPORT
		1440	0	30
17191	85	0	0	0
		0	1440	30
		0	1440	30
192401	10095	132	611	15
		1440	0	30
		1440	0	30
		1440	0	30
		1440	0	30
		1440	0	30
	1662	0	0	0
	546	0	0	0

LG 4222

FUTURE

- STAMP PACKAGES
- WCDO TONNAGE
- WHAT-IF EPSF'S
- AUTOMATED UPDATE OF RIF, IIC, XREF, CEMO
- WAA/WARCONFAC MATCH
- WHOLE ROUND MODIFICATION
- TARGET/TRANSPORTATION MODULE
- D078, CSMS, DFMS, WAA ON LINE INTERFACE

LG 4210

SUMMARY

- FIRST CONSOLIDATED DATA BASE FOR WAR CONSUMABLES
- WARTIME OR PEACETIME PLANNING
- MAJCOM WCDO

LG 4218

FOCAS
FORCE CAPABILITY ASSESSMENT SYSTEM

PRESENTED BY MAJ JAMES D. BLANCHARD, HQ TACOPS/DOCR

DO 6988

OVERVIEW

- BACKGROUND
- CONCEPT
- HOW IT WORKS
- OUTPUT
- STATUS
- FUTURE

DO 7715

BACKGROUND

- CSAF CONSTANT READINESS TASK 3-OPR-AF/XO

  "DEVELOP RESPONSIVE MEANS OF ASSESSING AND REPORTING COMBAT CAPABILITY."

- TAWC TACTICAL AIR READINESS GROUP-OPR FOR TAF

80 1750

CONCEPT

- BASIC UNIT OF MEASUREMENT
  - COMBAT SORTIE
- ELEMENTS QUANTIFIED THROUGH ALGORITHMS
- LIMITING FACTORS IDENTIFIED

DO 7716

DATA SOURCES

- USER INPUT
- TALI/WRM
- CSMS
- CEMO
- UNITREP
- TPFDL

DO 7722

MAJOR ELEMENTS

	SORTIE POTENTIAL		SORTIE POTENTIAL
• AIRCRAFT	75	• MUN ASSY & DIST CREWS	70
• AIRCREWS	80	• MUN ASSY & DIST EQUIP	65
• FUEL QUANTITY	500	• MUN LOAD EQUIP	50
• FUEL SERVICING	135	• LOAD CREWS	80
• SUPPORT EQUIPMENT	85	• TANKS	150
• ENGINES	90	• RACKS, ADAPTERS, PYLONS	250
• MUN QUANTITY	125	• WRSK	60

DO 6993

AIRFRAME DATA ELEMENTS

- ACFT POSSESSED
- FMC RATE
- NMCM RATE
- NMCS RATE
- NMCB RATE
- AVG SORTIE DURATION
- MAINT TURN TIME
- PREFLIGHT TIME
- TAXI TIME

- DEAD TIME
- ATTRITION RATE
- BATTLE DAMAGE TIME
- BREAK RATE
- SURGE ENVELOPE
- % DAMAGED REPAIRED OVERNIGHT
- % BROKEN REPAIRED OVERNIGHT

DO 6994

AIRFRAME DATA ELEMENTS

FACTUAL	HISTORICAL	REASONABLE ESTIMATE	GUESS
ACFT POSSESSED	FMC RATE	AVG SORTIE DURATION	ATTRITION RATE
PREFLIGHT TIME	NMCM RATE	MAINT TURN TIME	BATTLE DAMAGE RATE
TAXI TIME	NMCS RATE	DEAD TIME	% DAMAGED REPAIRED OVERNIGHT
	NMCB RATE	SURGE ENVELOPE BREAK RATE	% BROKEN REPAIRED OVERNIGHT

DO 6995

SLIDE 9

SUPPORT EQUIPMENT DATA

THIS IS ANOTHER SAMPLE OF ALGORITHM ELEMENTS, FOR SUPPORT EQUIPMENT - BASICALLY FLIGHT LINE AGE SUCH AS LOX CARTS AND STARTER UNITS.

SLIDE 10 L

SLIDE 10 R

NEXT I'LL EXPLAIN OUR PRIMARY OUTPUT REPORT, THE SORTIE POTENTIAL REPORT, SHOWN HERE. THIS SAMPLE SHOWS ONE UNIT OVER A PERIOD OF SIX DAYS OF CONFLICT. I'LL USE DAY ONE AS A WALK THROUGH EXAMPLE OF HOW THE REPORT IS READ AND USED. REMEMBER, THE NUMBERS IN THE COLUMNS, WITH THE EXCEPTION OF THE # OF WAVES, SCL IDENTIFICATION NUMBERS, NUMBER OF SCL'S TASKED, AND PERCENT OF SCL'S TASKED, SHOW POTENTIAL NUMBER OF SORTIES, NOT QUANTITIES OF THE NAMED ELEMENT. FOR DAY 1 THE ALGORITHMIC COMPUTATIONS SHOW AN AIRFRAME LIMFAC OF 57 SORTIES WITH AIRCRAFT AS THE LIMITING FACTOR. THE PROGRAMMED SCL TASKING HAS BEEN AS FOLLOWS, LISTED IN ORDER OF PREFERRED USE:

1ST PRIMARY (50% OF SORTIES)	AGM-65/20MM
2ND PRIMARY (25% OF SORTIES)	MK-20/20MM
3RD PRIMARY (25% OF SORTIES)	MK-82/20MM

UP TO THE AIRFRAME LIMFAC OF 60. IF THIS WAS POSSIBLE THEN THE WRSK LIMFAC OF 60 WOULD BE THE OVERALL UNIT LIMFAC.

THAT WAS A GENERAL OVERVIEW OF HOW THE PROGRAM WORKS MECHANICALLY. I WOULD NOW LIKE TO EXPLAIN THE ALGORITHM PROCESS IN MORE DETAIL USING THE AIRFRAME OR AIRCRAFT ALGORITHM AS AN EXAMPLE.

SLIDE 7

AIRFRAME DATA ELEMENTS

LISTED HERE ARE THE BASIC FACTORS/INPUTS WHICH ARE CONSIDERED IN THE AIRCRAFT ALGORITHM. (PAUSE - PROBABLE QUESTIONS).

SLIDE 8

AIRFRAME DATA ELEMENTS

THIS SHOWS THE TYPE OF SOURCES FROM WHICH THE DATA INPUTS COME. AS YOU CAN SEE, THE SOURCES RANGE FROM HARD FACTS TO SUBJECTIVE INFORMATION. IT SHOULD BE NOTED THAT THE HISTORICAL MC RATES ARE PEACETIME AND ARE USED AS ENTERING DATA FOR FIRST DAY ONLY. FOR SUBSEQUENT DAYS THE RATES ARE COMPUTED INTERNALLY. (PAUSE - PROBABLE QUESTIONS).

SLIDE 6

MAJOR ELEMENTS (TWO COLUMNS OF NUMBERS ARE ON A FLIP WHICH IS CALLED FOR LATER, AFTER THE INITIAL DISCUSSION.)

WE HAVE TWO TYPES OF ELEMENTS. SEVEN ARE GROUPED INTO WHAT WE CALL AIRFRAME FACTORS. THE REMAINING ARE MUNITIONS FACTORS. AIRFRAME FACTORS ARE THE FIRST SIX LISTED, ALONG WITH WRSK. EACH IS EVALUATED THROUGH THE ALGORITHMS FOR A GIVEN DAY AND THE SORTIE POTENTIAL IS DETERMINED. THE AIRFRAME FACTORS ARE COMPUTED FIRST. WHEN ALL HAVE

(FLIP)

BEEN COMPUTED AN "AIRFRAME LIMFAC" IS DETERMINED. IN THIS EXAMPLE WRSK WOULD BE THE LIMFAC FOR THIS DAY, WITH A POTENTIAL OF SUPPORTING, OR PRODUCING, 60 SORTIES. THIS AIRFRAME LIMFAC NUMBER (60) WOULD THEN BECOME THE NUMBER OF SORTIES AGAINST WHICH THE MUNITIONS FACTORS WOULD BE TASKED. TASKING IS BY STANDARD CONVENTIONAL LOADS (SCL's) PROGRAMMED IN ORDER OF DESIRED PRIORITY. IN THIS EXAMPLE THE MUNITIONS FACTORS FOR THE PRIMARY TASKED SCL COULD ONLY SUPPORT 50 SORTIES DUE TO A MUNITIONS LOAD EQUIPMENT LIMITATION. AT THIS POINT, IF NO OTHER SCL's WERE AVAILABLE TO THE UNIT, 50 WOULD BECOME THE LIMFAC. IF A SECONDARY SCL HAS BEEN PROGRAMMED THE PROGRAM WOULD STEP TO IT IN AN ATTEMPT TO FIND POTENTIAL FOR AT LEAST 10 MORE SORTIES -

SLIDE 5

DATA SOURCES

THE INPUT DATA COMES FROM THESE SOURCES. USER INPUTS ARE MANUALLY COLLECTED AND LOADED USING A VIP TERMINAL. THEY INCLUDE SUCH ITEMS AS RATES AND TIMES (EG; SURGE LENGTH) NOT FOUND IN AUTOMATED SYSTEMS. THE WRM PORTION OF THE TACTICAL ANALYSIS LOGISTICS INFORMATION SYSTEM PROVIDES CONSUMABLES DATA ON SUCH ITEMS AS FUEL ON HAND, FUEL TANKS, AND WHOLE ROUNDS. THE COMBAT SUPPLIES MANAGEMENT SYSTEM, IN CONJUNCTION WITH THE COMBAT FUELS SYSTEM PROVIDES DAILY UPDATES TO TALI ON NON-MUNITIONS TYPE CONSUMABLES, WHILE THE DO-78, NOT SHOWN HERE, PROVIDES THE UPDATE ON MUNITIONS. THE CONSOLIDATED EQUIPMENT MANAGEMENT OBJECTIVE INPUTS DATA ON BASE RESOURCES SUCH AS MUNITION HANDLING AND FUEL SUPPLY EQUIPMENT. THE UNITREP PROVIDES INFORMATION ON AIRCRAFT, AIRCREWS, PERSONNEL AND WRSK, ALL ON A DAILY BASIS. THE TPFDL - TIME PHASED FORCE DEPLOYMENT LIST - IN COMBINATION WITH LOGDET DATA PROVIDES MOBILIZATION AND AUGMENTATION INFORMATION SUCH AS UNIT AND UTC PACKAGE ARRIVAL DATES. THESE ARE THE DATA INPUT SOURCES. THE INFORMATION ONCE COLLECTED IS USED TO FEED ALGORITHMS FOR THE FOLLOWING EVALUATED ELEMENTS.

DEVELOPED FOR EACH OF 14 ELEMENTS. THESE WOULD USE SPECIFIC INPUT DATA AND EMPLOYMENT PARAMETERS FOR EACH ONE TO PRODUCE A SORTIE PER DAY POTENTIAL. BY SCANNING THE SORTIE POTENTIAL, OR "NUMBER OF SORTIES WORTH," OF EACH ELEMENT, SPECIFIC LIMITING FACTORS COULD BE EASILY IDENTIFIED. EFFORTS COULD THEN BE CENTERED ON THE PROBLEM AREA IN ATTEMPT TO RAISE ITS POTENTIAL.

FOLLOWING CONCEPT DEVELOPMENT AND TESTING OF THE INITIAL ALGORITHMS, DATA AUTOMATION PERSONNEL JOINED THE WORKING GROUP. BY LATE 1977 SOFTWARE PROGRAMMING OF THE ALGORITHMS HAD BEGUN. BY LATE 1978 A WORKABLE AUTOMATED SYSTEM HAD BEEN DEVELOPED WHICH PROCESSED DATA THROUGH THE ALGORITHMS AND PRODUCED SORTIE POTENTIAL AND INVENTORY REPORTS. ALSO INTERFACES WITH PARALLEL AUTOMATED DATA SOURCES HAD BEEN DEVELOPED WHICH PROVIDED THE BULK OF THE INPUT TO THE ALGORITHMS.

AND USAFE, ALSO WITHIN THEIR READINESS ORGANIZATIONS, MADE THE DECISION TO POOL THEIR EFFORTS IN DEVELOPMENT OF WHAT WE INVISIONED WOULD BE A TRI-COMMAND INPUT TO THE AIR STAFF SYSTEM. A TAF WORKING GROUP WAS FORMED IN 1977 TO DEVELOP A CONCEPT FOR MEETING THE CSAF TASKING. INITIALLY, OPERATIONS READINESS ORGANIZATIONS MANNED THE WORKING GROUP WITH LOGISTICS, PLANS, AND PERSONNEL PROVIDING MUCH SPECIALIZED EXPERTISE.

SLIDE 4

CONCEPT

CONCEPT DEVELOPMENT PROCEEDED THROUGHOUT 1977. THERE WERE FOUR THINGS WE WANTED IN THE SYSTEM: FLEXIBILITY (TO CHANGE INPUT PARAMETERS), USE OF ONLY PRESENTLY REPORTED DATA (NO NEW REPORTS TO BE GENERATED), SIMPLICITY IN DESIGN AND USE, AND RELATIVE LOW DESIGN COST.

WE DECIDED ON USING THE COMBAT SORTIE AS THE BASIC UNIT OF MEASUREMENT. INDIVIDUAL ELEMENTS WHICH CONTRIBUTE DIRECTLY TO SORTIE GENERATION IN A COMBAT SURGE ENVIRONMENT WERE IDENTIFIED. FOR EXAMPLE, AIRCRAFT, AIRCREWS, LOAD CREWS AND FUEL. ALGORITHMS WERE

SLIDE 1

TITLE

THIS PRESENTATION WILL COVER THE FORCE CAPABILITY ASSESSMENT SYSTEM, FOCAS FOR SHORT.

SLIDE 2

OVERVIEW

THESE ARE THE AREAS I WILL COVER. A BRIEF BACKGROUND ON WHERE AND WHY THE SYSTEM BEGAN AND WHO WERE THE ORIGINAL PARTICIPANTS; A LOOK AT THE BASIC CONCEPTS, PREMISES, AND RESTRAINTS EMPLOYED DURING DEVELOPMENT; HOW THE PROGRAM WORKS TOWARD PROVIDING THE OUTPUT REPORTS WE USE AND A WRAP UP WHICH WILL OUTLINE THE PRESENT STATUS AND FUTURE PLANS.

SLIDE 3

BACKGROUND

DURING THE "YEAR OF READINESS," 1976, AT THE CONSTANT READINESS CONFERENCE, EIGHT CONSTANT READINESS TASKINGS WERE DEVELOPED AND FORWARDED BY CSAF. ONE OF THESE WAS TO DEVELOP A RESPONSIVE MEANS OF ASSESSING AND REPORTING COMBAT CAPABILITY. AF/XO WITHIN ITS READINESS STAFF BEGAN WORK ON A PROGRAM CALLED AFIRMS - AIR FORCE INTEGRATED READINESS MEASUREMENT SYSTEM. THE TACTICAL AIR FORCES; TAC, PACAF,

FORCE CAPABILITY ASSESSMENT SYSTEM (FOCAS)

PRESENTED TO

LOGISTICS CAPABILITY ASSESSMENT SYMPOSIUM-82

16 MARCH 1982

BRIEFER: MAJOR JAMES R. BLANCHARD
TACOPS/DOCR
LANGLEY AFB, VA

FUTURE

- ALGORITHM REVISION
- ADDITIONAL SOFTWARE
  - WHAT IF CAPABILITY
  - TUTORIAL SUBSYSTEM
  - GRAPHICS CAPABILITY
- OPR/USERS
  - READINESS
  - OPERATIONS
  - LOGISTICS
  - PLANS

DO 7720

STATUS

- ON LINE AT TAC
- FORWARDED TO PACAF
  - ON HOLD
- FORWARDED TO USAFE
  - VALIDATION/CHANGES
  - INTERFACE PROBLEMS

DO 7719

OUTPUT REPORTS

- SORTIE POTENTIAL
- DAILY CONSUMABLES INVENTORY
- MUNITIONS INVENTORY
- TASKED SCL ELEMENTS
- SCL BUILDUP
- UNIT SUMMARIES
  - AIRCRAFT
  - AIRCREWS
  - MUNITIONS

DO 7718

DAY =	0	1	2	3	4	5
2ND PRIMARY SCL	38	38	38	38	38	38
# SCLS TASKED	14	14	10	11	8	7
% SCLS TASKED	25	25	25	25	25	25
MUNITION QTY	389	375	361	351	341	333
A+D CREWS	375	396	393	405	423	419
A+D EQUIP	558	572	583	595	605	630
LOAD CREWS	630	508	347	362	513	519
LOAD EQUIP	19*	198*	141*	147*	202*	200*
TANKS	527	526	526	525	525	524
R A P	1114	1114	1114	1114	1114	1114
GCC AIRCRAFT	-1	-1	-1	-1	-1	-1
GCC CREWS	-1	-1	-1	-1	-1	-1
LIMFAC	JAMMRB	JAMMRB	JAMMRB	JAMMRB	JAMMRB	JAMMRB
2ND SECONDARY SCL	42BW					
# SCLS TASKED	56					
% SCLS TASKED	100					
MUNITIONS QTY	798					
A+D CREWS	43*					
A+D EQUIP	258					
LOAD CREWS	662					
LOAD EQUIP	105					
TANKS	680					
R A P	1114					
GCC AIRCRAFT	-1					
GCC CREWS	-1					
LIMFAC	461XX					
3RD PRIMARY SCL	23	23	23	23	23	23
# SCLS TASKED	14	14	10	10	8	6
% SCLS TASKED	25	25	25	25	25	25
MUNITION QTY	73	67*	53*	43*	33*	25*
A+D CREWS	51	68	64	65	74	70
A+D EQUIP	139	141	148	149	149	150
LOAD CREWS	289	233	159	166	236	234
LOAD EQUIP	6*	177	129	135	182	170
TANKS	513	513	512	512	511	511
R A P	1114	1114	1114	1114	1114	1114
GCC AIRCRAFT	-1	-1	-1	-1	-1	-1
GCC CREWS	-1	-1	-1	-1	-1	-1
LIMFAC	JAMMRB	MK 82	MK 82	MK 82	MK 82	MK 82

SORTIE POTENTIAL REPORT

AIRFRAME FACTORS	0	1	2	3	4	5
ROLE						
# OF WAVES	3.60	4.79	3.52	3.48	2.90	2.01
AIRCRAFT	69	57*	40*	43*	36	32
WRSK	85	70	47	46	32*	26*
AIRCREWS	100	88	56	55	51	45
FUEL QTY	4645	4671	4734	4818	4906	5304
FUEL SVCS	575	585	354	365	383	391
ENGINES	80	75	54	57	49	40
SUPT EQUIP	56	76	40	45	51	43
ITEM	TUG/TB	TUG/TB	TUG/TB	TUG/TB	TUG/TB	TUG/TB
1ST PRIMARY SCL	90	90	90	90	90	90
# SCLS TASKED	28	29	20	22	16	13
% SCLS TASKED	50	50	50	50	50	50
MUNITION QTY	64	50	50	50	50	39
A+D CREWS	34	48	57	59	58	57
A+D EQUIP	14*	0*	0*	0*	11*	13*
LOAD CREWS	376	304	210	220	303	290
LOAD EQUIP	20	195	135	141	196	185
TANKS	541	540	540	540	540	539
R A P	360	360	360	360	360	360
GCC AIRCRAFT	-1	-1	-1	-1	-1	-1
GCC CREWS	-1	-1	-1	-1	-1	-1
LIMFAC	JAMMRB	JAMMRA	JAMMRA	JAMMRA	JAMMRA	JAMMRA
1ST SECONDARY SCL	81	81	81	81	81	
# SCLS TASKED	56	57	40	43	32	
% SCLS TASKED	100	100	100	100	100	
MUNITION QTY	518	518	489	469	446	
A+D CREWS	27	58*	61*	63*	62*	
A+D EQUIPMENT	406	469	478	501	557	
LOAD CREWS	465	376	257	268	379	
LOAD EQUIP	0*	11777	8637	8969	12455	
TANKS	507	459	422	396	377	
R A P	99999	99999	99999	99999	99999	
GCC AIRCRAFT	-1	-1	-1	-1	-1	
GCC CREWS	-1	-1	-1	-1	-1	
LIMFAC	JAMMRB	JAMMRB	461XX	461XX	316XX	

DC 7717

SUPPORT EQUIPMENT DATA

- CAN ACCOMMODATE 15 TYPES OF SORTIE GENERATION EQUIPMENT
- DATA ELEMENTS
  - NAME
  - RESUPPLY
  - ON HAND
  - FMC RATE
  - EMPLOYMENT FACTOR
  - ITEM USE RATE

DO 6996

	1ST SECONDARY (100% OF SORTIES)	MK-84 LGB
	2ND SECONDARY (100% OF SORTIES)	CBU/20MM
(NOT SHOWN)	3RD SECONDARY (100% OF SORTIES)	20MM ONLY

UP TO NINE SCL'S MAY BE PROGRAMMED WITH THE UNIT AUTHORIZED A MIX, BY PERCENTAGE, OF THE FIRST THREE (PRIMARIES). THE REMAINDER, IF PROGRAMMED ARE ALL ASSIGNED 100% TO INSURE MAXIMUM UTILIZATION AS BACKUPS SHOULD ANY OR ALL OF THE PRIMARIES SHOW A CAPABILITY LESS THAN THAT TASKED.

IN THIS EXAMPLE WE HAVE TASKED SCL 90 (1ST PRIMARY) TO BE USED ON 50% OF THE SORTIES. THIS EQUATES TO 29 SORTIES BASED ON THE 57 AIRFRAME LIMFAC. SCL 38 (2ND PRIMARY) IS TASKED FOR 25% OR 14 SORTIES. LIKEWISE SCL 23 (3RD PRIMARY). WE SEE THAT SCL 90 CANNOT BE SUPPORTED DUE TO ZERO POTENTIAL IN MUNITIONS ASSEMBLY AND DISTRIBUTION EQUIPMENT. THE SPECIFIC PIECE OF EQUIPMENT IS IDENTIFIED AS JAMMERS AT THE BOTTOM OF THE SCL COLUMN. SCL 38 HAS A LIMFAC OF 198 DUE TO LOAD EQUIPMENT BUT THIS ALLOWS ALL 14 OF TASKED SORTIES TO BE SUPPORTED. SCL 23 HAS A LIMFAC OF 67 DUE TO MUNITIONS QUANTITY WHICH ALSO ALLOWS ALL 14 TASKED SORTIES TO

BE SUPPORTED. THE PROGRAM WILL THEN STEP TO THE 1ST SECONDARY SCL (81) TO PRODUCE THE REMAINING 29 SORTIES WHICH SHOULD HAVE BEEN FLOWN WITH SCL 90. THE LIMFAC FOR SCL 81 IS IN ASSEMBLY AND DISTRIBUTION CREWS, BUT MORE THAN THE NEEDED 29. SO WE SEE THAT ALL THE SORTIES CAPABLE OF BEING FLOWN BY THE AIRCRAFT CAN BE SUPPORTED BY MUNITIONS, ALTHOUGH NOT EXACTLY IN THE PREFERRED ORDER. THE PROGRAM WILL THEN ADD ANY RESUPPLY OF RESOURCES, DECREMENT CONSUMABLES BASED ON SORTIES FLOWN AND USE THIS DATA AS PART OF THE ENTERING ARGUMENTS TO RUN THE ALGORITHMS FOR THE NEXT DAY. UP TO 10 DAYS OF MOBILITY (ALLOWING FOR MOVEMENT OF RESOURCES AND BUILDING OF MUNITIONS) AND 30 DAYS OF CONFLICT MAY BE PROGRAMMED AND RUN. BOTH SPANS ARE USER SELECTABLE. USING AN INTERACTIVE SUBSYSTEM, AT A VIP TERMINAL, THE USER MAY MAKE ANY NUMBER OF CHANGES TO THE VARIOUS DATA BASES, RERUN THE COMPUTATIONS AND BE PROVIDED WITH NEW OUTPUTS, WITHIN MINUTES. THIS ALLOWS FOR "WHAT-IF GAMMING" TO ANALYZE IMPACTS OF CHANGES IN PARAMETERS OR IN RESOURCE DISTRIBUTION AND UTILIZATION.

SLIDE 11

OUTPUT

WHILE THE SORTIE POTENTIAL REPORT IS OUR PRIMARY OUTPUT, THERE ARE SEVERAL OTHER REPORTS WHICH BEAR MENTIONING. THE DAILY CONSUMABLES INVENTORY LISTS ALL THE NON-MUNITION CONSUMABLES (EG: FUEL TANKS, RAP) ON HAND, INBOUND, AND END OF DAY TOTAL. THE MUNITIONS INVENTORY LISTS MUNITIONS IN THE SAME WAY. THE TASKED SCL ELEMENTS REPORT PROVIDES A SORTIE POTENTIAL FOR EACH SUB-ELEMENT. FOR EXAMPLE, EACH TYPE OF LOAD EQUIPMENT OR LOAD CREW AFSC. THIS REPORT IS INVALUABLE AT THE FUNCTIONAL OPR LEVEL TO ANALYZE SPECIFICALLY WHAT MAY BE CAUSING A MAJOR ELEMENT TO BE A LIMFAC AND WHAT STEPS COULD BE TAKEN TO RAISE ITS POTENTIAL. THE SCL BUILDUP PRESENTS A BY DAY SCL COUNT SHOWING THE REQUIREMENT, HOW MANY CAN BE BUILT UP FROM ON HAND STOCK, HOW MANY WERE USED, AND HOW MANY REMAIN AVAILABLE BUT NOT BUILT UP. WHEN THERE IS MORE THAN ONE UNIT OPERATING AT A SINGLE BASE THE UNIT SUMMARY ADDS THE POTENTIAL OF AIRCRAFT, AIRCREWS, AND MUNITIONS OF ALL LIKE AIRCRAFT UNITS AND SHOWS A TOTAL FOR EACH CATEGORY FOR EACH BASE AND AIRCRAFT TYPE.

SLIDE 12

STATUS

THE ORIGINAL PROGRAM WITH SOME CHANGES IS ON LINE AT HQ TAC AND WAS FORWARDED TO PACAF AND USAFE. PACAF IS WITHHOLDING FULL IMPLEMENTATION PENDING VERIFICATION OF A NEW USER'S MANUAL AND TESTING/RECEIPT OF ADDITIONAL CHANGES PROPOSED BY USAFE. USAFE HAS PUT THE PROGRAM THROUGH A LONG AND STRINGENT TEST AND EVALUATION PHASE WHERE SEVERAL PROGRAMMING PROBLEMS WERE IDENTIFIED. THESE HAVE BEEN REWORKED AND CHANGE PROPOSALS HAVE BEEN FORWARDED TO TAC FOR INCORPORATION. ADDITIONALLY, USAFE HAS FOUND INCOMPATABILITY PROBLEMS WITH SOME OF THEIR REPORTING SYSTEMS (EG; MUNITIONS REPORTING). SINCE AUTOMATED REPORTS FEED MUCH OF THE FOCAS DATA THESE INTERFACE PROBLEMS MUST BE WORKED OUT PRIOR TO IMPLEMENTATION. THIS IS IN WORK NOW.

SLIDE 13

FUTURE

AS JUST DISCUSSED, OUR IMMEDIATE FUTURE WILL DEAL WITH IMPLEMENTING THE ALGORITHM SOFTWARE CHANGES AND ASSISTING USAFE WITH SOLVING THEIR INTERFACE PROBLEMS. TAC/AD WILL THEN BEGIN WORK ON THREE NEW SUBSYSTEM PROGRAMS. THE "WHAT-IF" SUBSYSTEM WILL PROVIDE AN

AUTOMATIC AND ITERATIVE CAPABILITY TO CHANGE PARAMETERS AND DATA BASES. THE TUTORIAL SUBSYSTEM WILL PROVIDE USERS ASSISTANCE VIA SCREEN DISPLAY EXPLANATIONS WHILE WORKING AT A TERMINAL. THE GRAPHICS SUBSYSTEM WILL PRODUCE LINE AND BAR GRAPHS DEPICTING THE INFORMATION AVAILABLE IN ANY OF THE OUTPUT REPORTS.

ALTHOUGH THE OPERATIONS AND READINESS ORGANIZATIONS HAVE BEEN MOST INVOLVED IN DEVELOPING FOCAS, AND WILL CONTINUE TO USE IT, I BELIEVE THAT IT WILL ALSO BECOME AN IMPORTANT TOOL IN OTHER AREAS SUCH AS LOGISTICS AND PLANS. MOST PROBLEMS, ONCE IDENTIFIED, HAVE LOGISTICS IMPLICATIONS AND CAN ONLY BE SOLVED WITHIN THE LOGISTICS COMMUNITY. WE CAN USE IT TO EVALUATE THE FEASIBILITY OF EXISTING PLANS BASED ON REAL WORLD FACTORS. IF A PLAN IS NOT COMPLETELY WORKABLE BASED ON RESOURCE ALLOCATIONS OR TIMING OF MOVEMENTS, IT CAN ASSIST IN DETERMINING HOW TO ADJUST THE PLAN OR HOW TO BETTER ALLOCATE RESOURCES TO SUPPORT IT.

PRESENTED BY MAJ C. L. BRAGAW, HQ MAC/XPSR.

MILITARY AIRLIFT COMMAND COMPUTER SYSTEM SIMULATION

- The Military Airlift Command (MAC) uses computer system simulation to better understand the behavior of the military airlift system over a wide range of operational configurations.

  -- System environment is controllable to allow experiments.

  -- Experiments are repeatable to obtain statistical measures of central tendency, scatter, and confidence.

  -- Interactive effects of the total system may be studies.

  -- No problems concerning safety, politics, disruptions to current system, mobilization, etc.

  -- Low cost; e.g., one trial of a 60-day Southwest Asia scenario may be run with all MAC resources that M-14 represents at the cost of approximately $750/random seed plus $1,000/experiment for TDY cost, if classified.

- MAC has used system simulation for various studies since 1975.

  -- Aircrew ratios, C-141 force realignments, C-141B productivity analysis, Blue/Gold aircrew concepts, importance of Goose AB.

  -- Under RIG auspices, model M-13 used unsuccessfully in 1977 in attempt to quantify MAC's surge capability.

    --- Failure due to notionalization.

    --- Outcome was the start of the development of M-14 in September 1977.

- M-14 is the most comprehensive computer simulation of MAC ever attempted.

  -- With over 400 airbases worldwide, each with its own base-level detail, M-14 can "execute" multiple war plans simultaneously.

  -- Currently configured for wartime, intertheater aspects of airlift operations; peacetime and intratheater to follow.

  -- M-14 airbases have runways, ramps, and fuel facilities; also aerial port and maintenance teams.

  -- M-14 tracks discrete aircrews and aircraft.

    --- Corrections made to aircraft flying times for airways routing, turn points, and area denials.

    --- Aircrew daily, monthly, and quarterly flying restrictions honored.

    --- An aircraft will wait if, during simulated execution, the resources needed are being used by other aircraft forming bottlenecks.

-- M-14 has an automatic scheduler that plans individual aircraft missions within the "real-time" state of the scenario.

--- Selects load and then routes to destination within aircrew staging and other policies.

--- Honors latest arrival date and cargo priority.

--- Looks ahead and plans routes to avoid station saturation and to use idle resources.

---- Model perhaps uses better information than command and control system can provide.

--- Plans air refueling (AR) according to user-stated policy.

--- Monitors missions and updates itineraries for late aircraft and creates new ones for diverted aircraft (failed AR; low ceiling/visibility; saturated ramp).

-- M-14 produces detailed data bank.

--- Records time of every event that happens to each aircraft.

--- Records movement requirement history.

--- Records waiting time statistics by resource type.

--- Records all mission itineraries for every aircraft to include both what was planned and what happened during execution. Information recorded includes airbases along the route, payload, fuel onloads required, crew staging, stop reasons, and planned/actual block times--also service/waiting times for maintenance and loading activities.

--- Retrievals made against these data banks as necessary to answer the original and follow-on questions.

-- Data reliability and validity for ground activities most vexing problem to date.

--- Most data derived from peacetime experience.

--- Flying times between bases are valid, but data for ground activities merit further investigation.

-- Logistics data recently reviewed.

--- Activities modeled are inspections (through-, post-, and pre-flight; isochronal); unscheduled maintenance (at home station and away); off-station supply; and refueling.

--- A8066A data from Maintenance Data Collection System used to estimate frequency, location, duration, and personnel demand of unscheduled maintenance.

---- Only Minimum Equipment Subsystem List (MESL) discrepancies extracted.

-- Functional area experts from MAC Staff used to:

--- Describe functional area to modelers.

--- Provide inputs for M-14 operations.

--- Exact "tests of reasonableness" on model outputs.

-- During validation, several studies undertaken.

--- Sizing the AR-qualified aircrew force for Program Objective Memorandum input.

--- OSD/PA&E study on C-5 surge capability after wing modification.

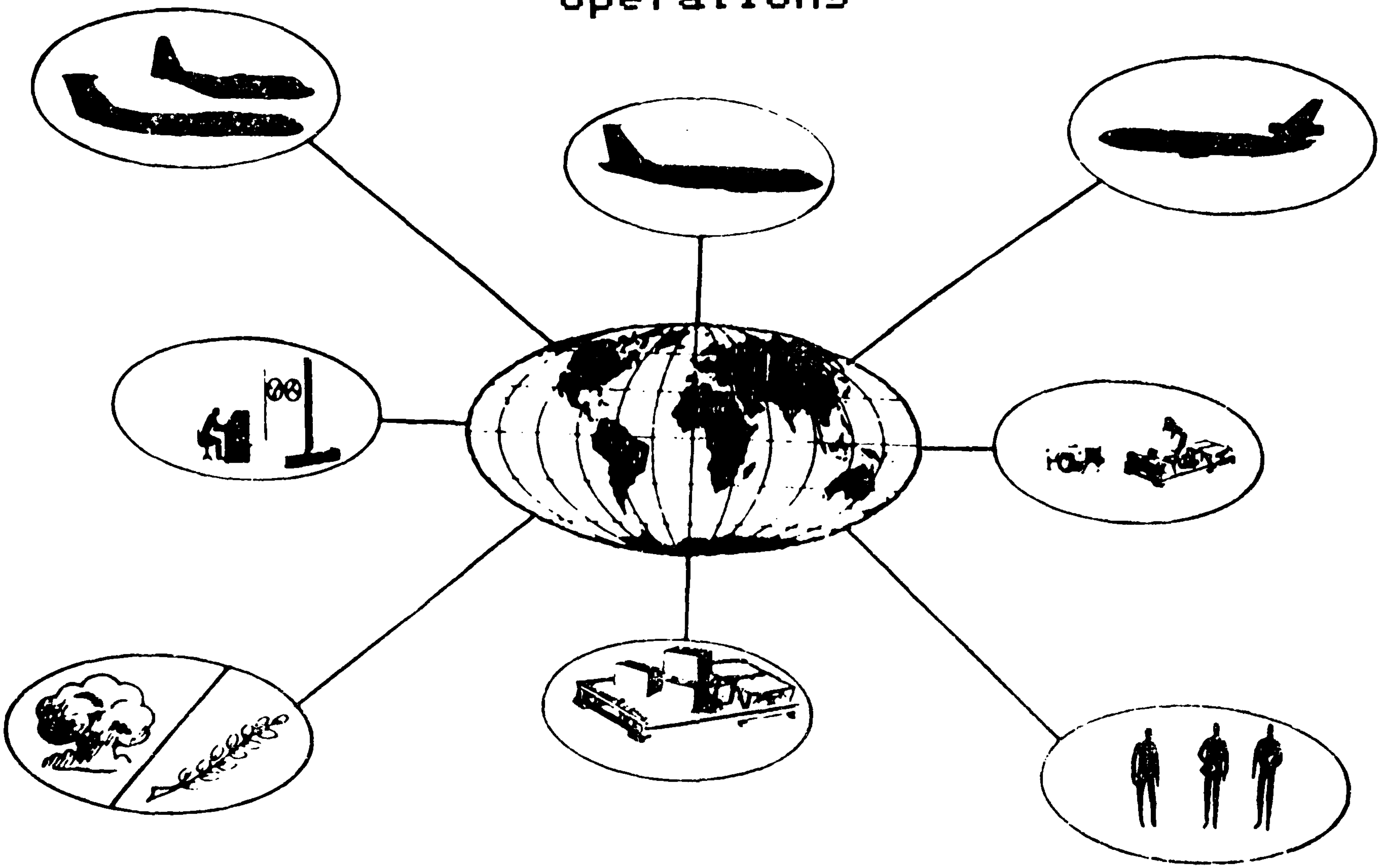
--- Impact of ceiling/visibility on airlift operations to Europe.

-- M-14 has potential as:

--- Training tool for Crisis Action Teams.

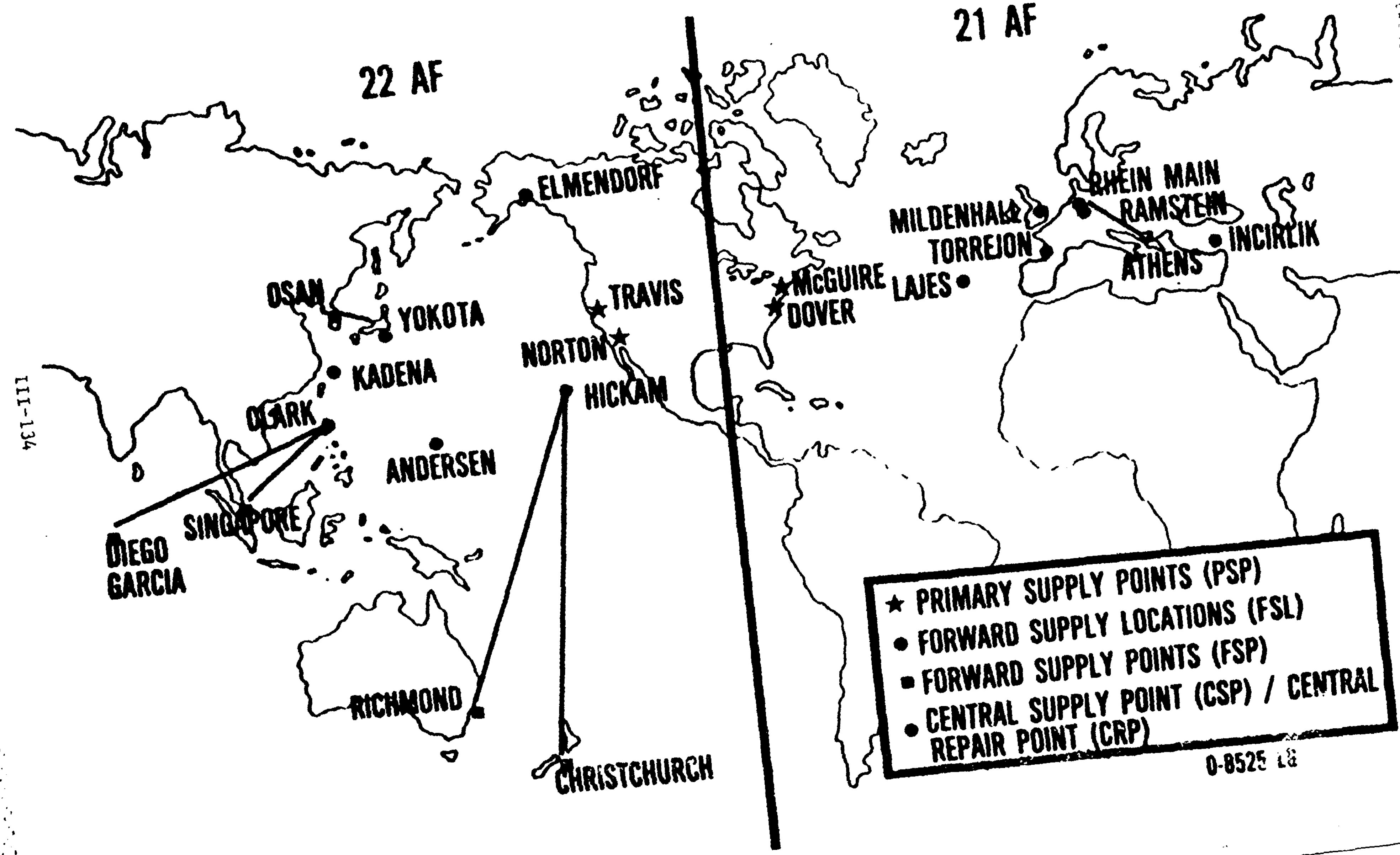
--- Answering "what ifs" during contingency execution.

Maintenance and Supply Considerations In Modeling Intertheater Military Airlift Operations

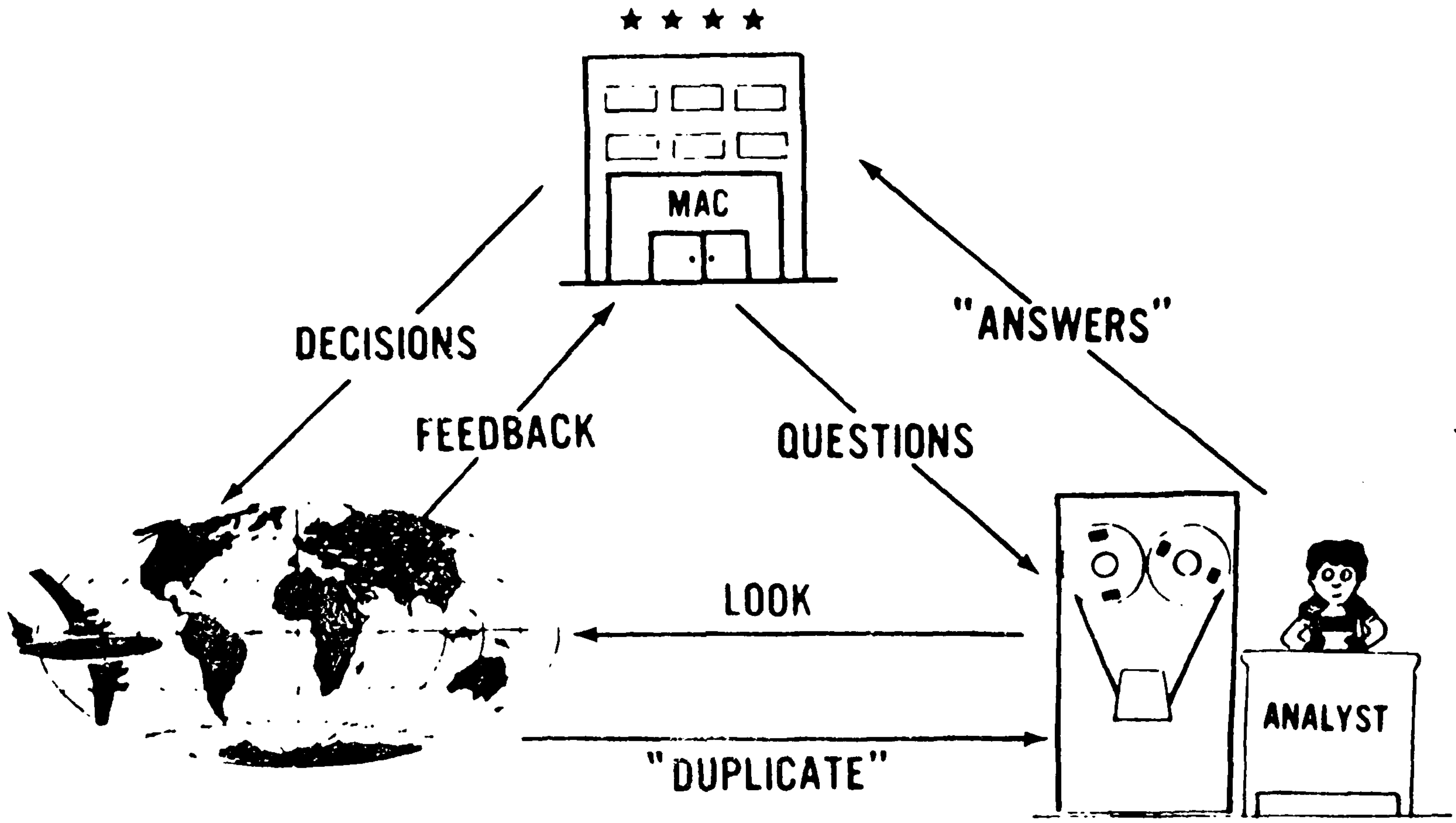


0 1875 XP

AREA OF OPERATION



SYSTEM SIMULATION: A MANAGEMENT TOOL



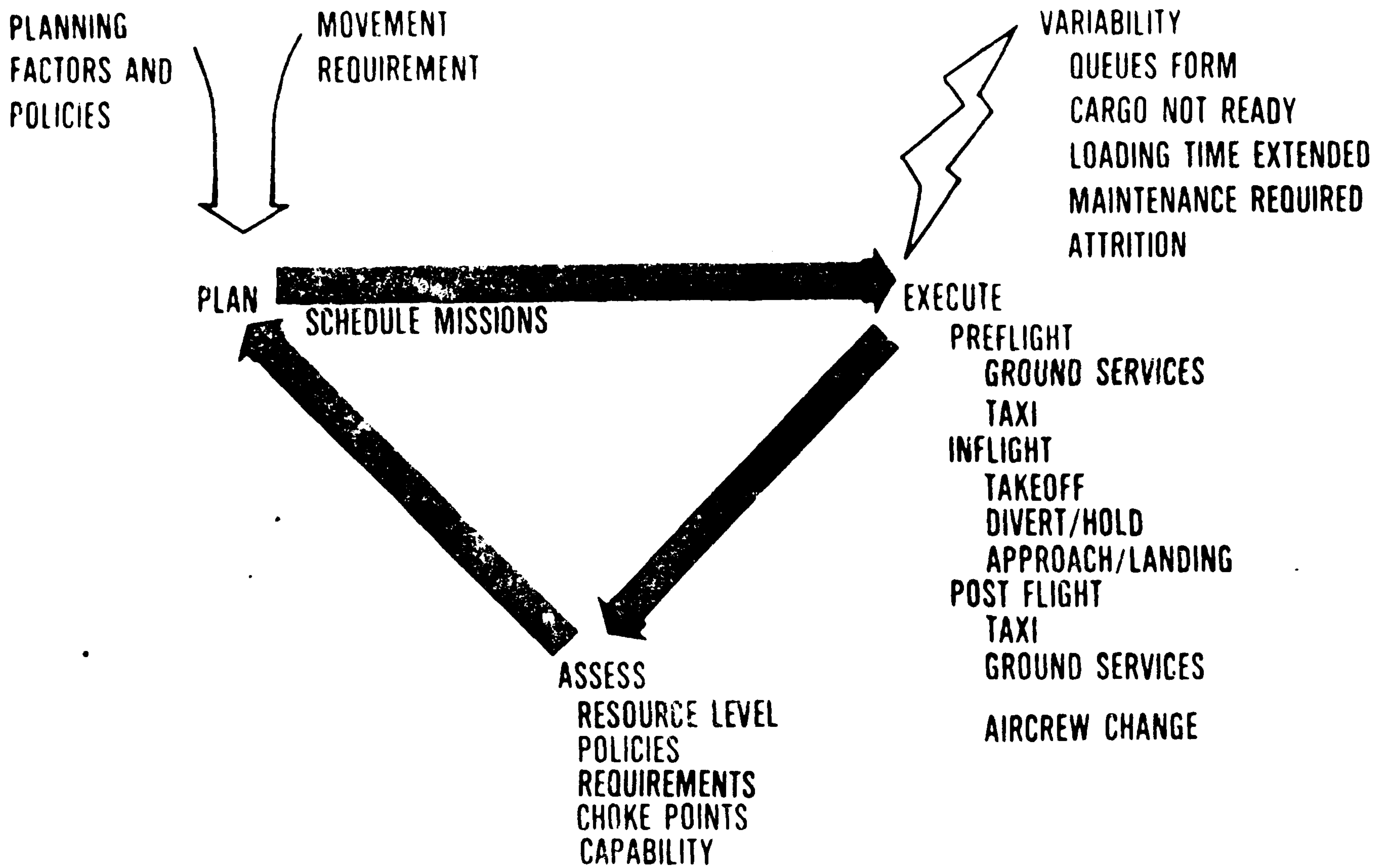
5143 XP

MAJOR MAC RESOURCES IN M-14

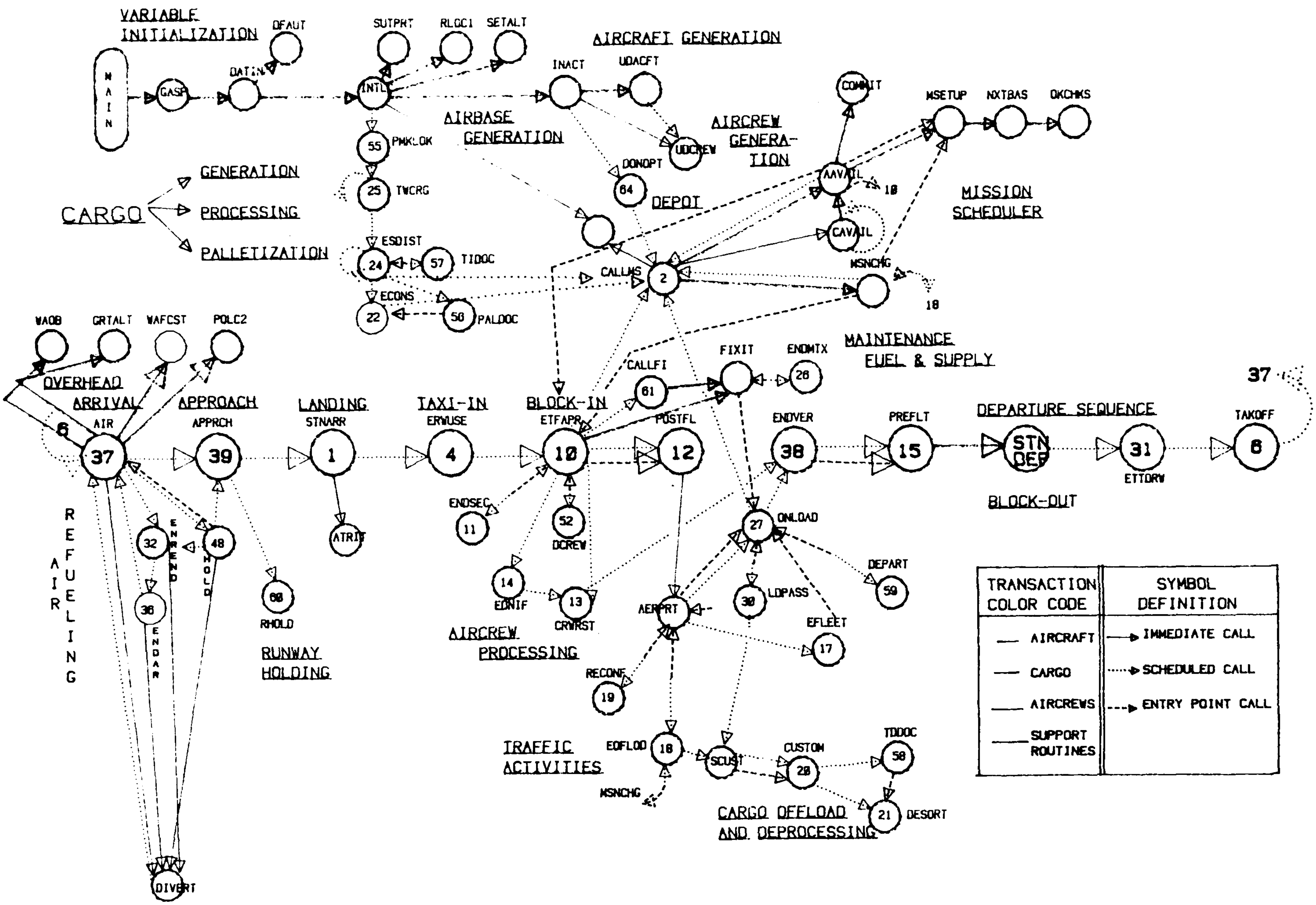
BASE (422)	EQUIPMENT	PERSONNEL
RUNWAYS	AIRCRAFT (703)	AIRCREWS (2812)
RAMPS	270 C-141 76 C-5	MAINTENANCE
FUEL PITS/TRUCKS	$\left.\begin{array}{l}\text{143 NBC}\\ \text{214 WBC}\end{array}\right\}$ CRAF	AERIAL PORT
BOQ ROOMS	MATERIALS HANDLING EQUIPMENT	FLEET SERVICE
		SECURITY
		CUSTOMS

0 12490 XP

M-14 OPERATION



1 9986 XP


VARIABLE INITIALIZATION
MAIN
GASP
DATIN
DFAUT
SUTPRT
RLGC1
SETALT
INTL
55 PMKLOK
25 TWCRG
24 ESDIST
57 TIDOC
22 ECONS
58 PALDOC
AIRBASE GENERATION
AIRCRAFT GENERATION
INACT
UDACFT
UDCREW
AIRCREW GENERATION
64 DONOPT
DEPOT
CALLMS
2
CARGO
GENERATION
PROCESSING
PALLETIZATION
COMMIT
AAVAIL
18
CAVAIL
MSNCHG
MSETUP
NXTBAS
OKCHKS
MISSION SCHEDULER
MAINTENANCE FUEL & SUPPLY
WAOB
GRTALT
WAFCST
POLC2
OVERHEAD ARRIVAL
APPROACH
LANDING
TAXI-IN
BLOCK-IN
AIR
37
6
APPRCH
39
STNARR
1
ATRIT
ERWUSE
4
ETFAPR
10
CALLFI
61
FIXIT
ENDMTX
26
POSTFL
12
ENDVER
38
PREFLT
15
DEPARTURE SEQUENCE
STN DEP
31 ETTORW
TAKOFF
8
BLOCK-OUT
AIR REFUELING
32 ENRENG
48 HOLD
36 ENDAR
DIVERT
68 RHOLD
RUNWAY HOLDING
ENDSEC 11
52 DCREW
14 EDNIF
13 CRWRST
AIRCREW PROCESSING
27 ONLOAD
30 LDPASS
DEPART 59
EFLEET 17
AERPRT
RECONF 19
TRAFFIC ACTIVITIES
EOFLOD 18
MSNCHG
SCUST
CUSTOM 28
TDDOC 58
21 DESORT
CARGO OFFLOAD AND DEPROCESSING
TRANSACTION COLOR CODE
AIRCRAFT
CARGO
AIRCREWS
SUPPORT ROUTINES
SYMBOL DEFINITION
IMMEDIATE CALL
SCHEDULED CALL
ENTRY POINT CALL

IV. BALANCED PROGRAM METHODOLOGY

This section of the paper describes the processes used to develop the balanced program methodology and briefing. We will indicate the methods used and sources of data and individuals contacted in developing the briefing.

The format of the methodology discussion is as follows. First, we discuss how current capability estimates were developed for each of the major logistics components considered in this initial analysis (reparable spares, munitions, and fuel). We then discuss how capability and budgets can be related in the balanced program methodological approach. Next, we show how the various programs can be brought together in a balanced program analysis.

A. CURRENT CAPABILITY -- PRINCIPAL LOGISTICS COMPONENTS

1. Background

Before considering items unique to each asset, it is important to describe requirements and capability in general terms. Requirements are specified in terms of total flying hours per unit time period, usually for each day of the hypothesized war. These are displayed graphically, as in Figure 1, with total flying hours per time period on the left-hand side (ordinate), and days of the conflict on the bottom of the graph (abcissa). Shown on this graph is a profile of the flying hours over the days of the conflict. One of these graphs is developed for each aircraft/theatre/scenario combination. Throughout most of the analysis, we focus upon the most demanding combination (i.e., that with the maximum requirements such as the tactical air force, in the European theatre, under the NATO scenario). The requirements line then displays total required flying hours, as defined by the XO War Mobilization

Addressing these issues was another time-consuming, but extremely important, aspect of this development. A further constraint was that we had to be able to aggregate or disaggregate to the desired level of aircraft, theatre, and scenario combinations for any particular plan.

Further complicating the process was the critical need to produce results along with the methodology. Almost as soon as we developed a concept, it was necessary to apply it to the real situation. This was required both to test the reasonableness of the approach and as a "selling" device to convince others that the methodology was suitable. Therefore, the effort has evolved using real numbers wherever possible. The advantage of doing this is that we have been forced to use existing data and data systems without any support explicitly allocated for those inputs. In other words, we have gathered whatever was available and turned it into results consistent with our methodology. We have learned, as a result, how to integrate this information in an automated fashion which should alleviate, instead of create, work for the program offices.

With the automated system, personnel will be able to run different scenarios and excursions very quickly instead of requiring the program offices to redo their analyses each time. In addition to minimizing the analytical requirements, we are not imposing new data requirements on the program offices unless absolutely necessary. We are using existing data and results from analysis already done for other purposes. In some cases, we now recalculate, by hand, model results or aggregate them in a certain fashion. In the future, this work will be automated. Therefore, the inputs to the balanced program model which we will request of program offices are likely to be items which they are producing.

III. THE DEVELOPMENT OF THE METHODOLOGY AND BRIEFING RESULTS

The development of the balanced program methodology was both time consuming and productive, beginning "from the ground up." That is, the individual program offices who were responsible for developing capability estimates were partners in the analysis. We took their capability and budget estimation approaches and tried to do two things with them. First, we analyzed their existing capability assessment approaches to determine their strengths and shortcomings. We also tried to determine the possibility of automating the process and for aggregating and disaggregating the results. We then adopted the best parts of their methodology, added our own where needed, and modified it all to fit together in a balanced program approach.

At each step, extremely close coordination with the individual program offices was stressed. The principal LEXY and Synergy analysts recognized early that the support of the program offices was essential. Such close coordination was time consuming, but we now have a methodology which each of the individual program offices believes in and supports.

The products developed had to be consistent both with detailed individual program office capability estimates, and with aggregate information used to support decisions in the board structure and throughout the Air Staff. This required assembling the detailed, coordinated information and developing a format which could be used to explain and support budget allocation decisions. Furthermore, the program measures had to be reduced to a common denominator to permit proper comparison across logistics components. Previous program approaches did not address adequately the "least common denominator" problem or the appropriate level of aggregation in which to describe the results.

techniques to other logistics components.

In addition to the increased need for better analysis of individual assets, there is a renewed emphasis in the Air Staff and DOD in general on balancing the programs. This implies that no one resource should have a capability which significantly exceeds the capability of other resources which may be needed for the same mission. For example, a stock of munitions adequate for 180 days is of little value if jet fuel supplies will run out after day 45. Since the performance of the mission of the Air Force requires the joint application of all logistics components, resources may be misallocated if any one asset is evaluated without also considering related components after this balancing process. This balancing issue has been raised before, but this effort represents the first systematic attempt to study it. The current POM is a better balanced program from a logistics point of view than any of its predecessors. Moreover, it is apparent that the emphasis on balancing will become stronger, requiring new analytical tools and presentation methods.

The potential for impact on public policy is high. In the last POM, with preliminary results of our analyses using manual techniques, several individuals involved in the program review process asked for our presentation and the analytical approach to help allocate resources. For the 84-88 POM, we have been developing an enhanced quick-response capability, anticipating substantial demands upon our models. The devices we have developed for balanced programs are useful for graphical description of the funding profiles in various other programs. Individual program offices have supported these efforts since they were developed in conjunction with them.

as a prototype for methods to integrate munitions, fuel, and spares capabilities and budgets in a multiple program analysis for use in the POM.

At the time this study was initiated, the potential for success was unknown. Air Staff officers and Synergy were asked to investigate this problem, and within 3-4 months develop a methodology and apply it on a preliminary basis. We believe we achieved this goal. We developed a methodology and prepared a major applications briefing which was shown to several members of the Air Staff, and portions of it were presented to the Air Force Council and to the Secretary of the Air Force. Since that initial briefing development, the outputs have been refined and have received widespread attention from the Air Staff, OSD, other services, OMB, and the Congress.

A strong foundation for the acceptance of this briefing existed because of the wide acceptance of the LCMS on the Air Staff and in OSD. The substantial effort devoted to analyzing spares, which appears to be the most difficult logistics component to model, eased its ready acceptance. In addition, LEXY and Synergy developed some powerful graphical and other visual techniques which independently have received substantial acceptance throughout the Air Staff.

These spares analyses and presentations have helped improve spares funding. To the extent that spares and other logistics assets compete for funds, the analysis and presentation for all other assets must also be more advanced. We feel that, if done appropriately, all logistics assets will be better supported in the budget process by the use of this sort of process. Therefore, we feel the timing is especially propitious to extend LCMS

II. BACKGROUND -- THE NEED AND POTENTIAL FOR BALANCING LOGISTICS PROGRAMS

In the initial development of the LCMS, the major emphasis was placed on examining reparable spares. In the early stages of spares analysis, attempts were made to consider the relationships between reparable and consumable spares and to incorporate the repair process (DPEM) into reparable spares models. These early efforts were successful; however their dilution of the main task of reparable spares modeling was unacceptable.

In support of sortie surge exercises, Synergy also developed a small model named the Logistics Pricing Model (LPM). The LPM assessed the demand for various logistics components and their associated costs under alternative scenarios. The model was well-suited to "what-if" analyses. The LPM was a less-sophisticated, automated first generation version of the current balanced programs model. These early efforts were successful; however, they were treated as excursions from the main task of modeling reparable spares. Recent demands for balanced resource planning have increased the requirement that spares be balanced with other resources.

This current effort was initiated with assignments from Gen. Broadwater and Mr. DelVecchio of HQ USAF/LEX. LCMS spares models and the presentation of reparable spares requirements were being well received in budget and POM deliberations within the Air Staff. In contrast, the requirements for other logistics components were not as well understood nor as clearly presented, and the LEX management desired to present each of the principal logistics components on a comparable basis. The initial tasking was to determine the possibility of developing analytically sound, quick-response LCMS-type munitions and fuel capability and budget estimates. This effort was to serve

BALANCED RESOURCE PLANNING:
METHODOLOGY AND MODELS[1]

By:

Mr. Donald L. Zimmerman
Col. Richard Olson
Lt. Col. William Smiley
Dr. Terrence R. Colvin

I. SUMMARY

During the 1983-87 POM development cycle, the Air Force was successful in presenting a resource expenditure plan directly related to operational capability that balanced multiple individual logistics programs. The analytical approach, specific methods, and resulting graphical displays supporting this were developed jointly by HQ USAF/LEXY and Synergy, Inc. The Balanced Resources Model stems from this work and is a part of the Logistics Capability Measurement System (LCMS). The model builds upon and is consistent with existing models and data bases. The Overview Model (described in a paper by Terrence R. Colvin at LOGCAS 81) continues as the key model for reparable spares capability assessment.

In addition to spares, the model now focuses upon petroleum, oil, and lubricants (POL) and air-to-ground munitions. Other logistics resources are recognized as critical to readiness and sustainability and are planned for inclusion at a later date.

---

[1] This paper was presented at the USAF Logistics Capability Assessment Conference (LOGCAS 82) in March, 1982. This paper does not address USAF uses of, or results of, the model.

A Prescriptive Model for Resource Allocation

at the Intermediate Level Engine Facility

Captain Edward Connolly

HQ MAC/LGXA

Scott AFB, IL 62225

Paper Not Included.

For further information, contact the author at

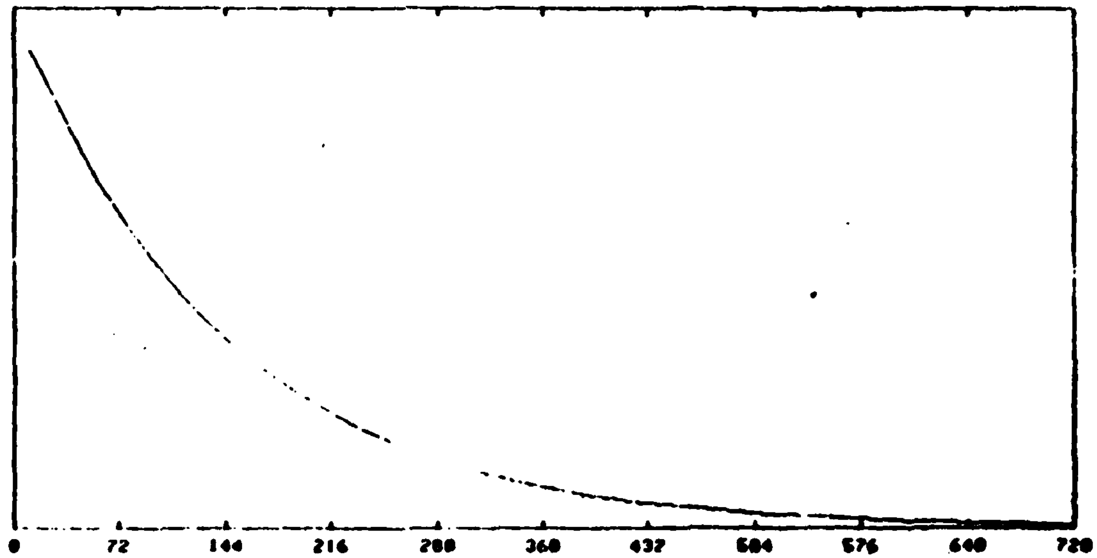
Autovon 638-5633

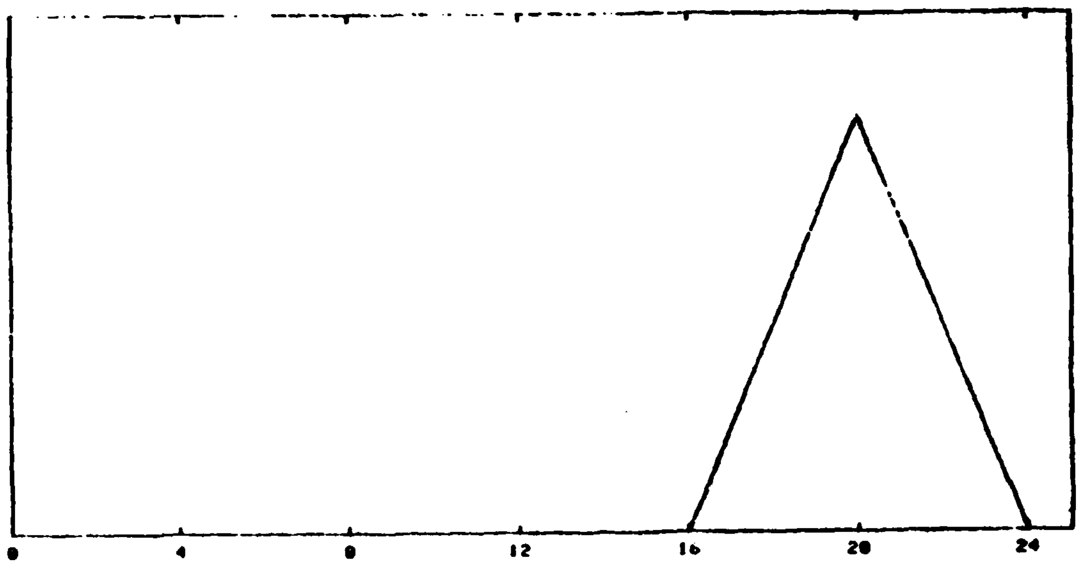
Commercial (618) 256-5633

OFF-STATION SUPPLY

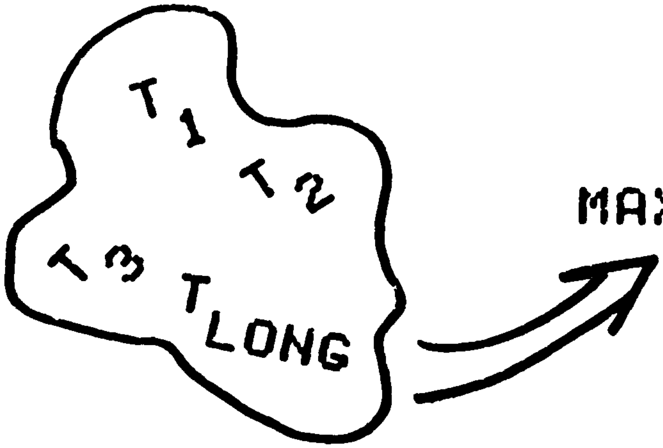
	FREQUENCY (% OF LANDINGS)	
	C-5	C-141
HS	4.8	3.5
MOB	4.2	1.0
FOB	5.2	0.9

DURATION





TOTAL UNSCHEDULED MAINTENANCE TIME



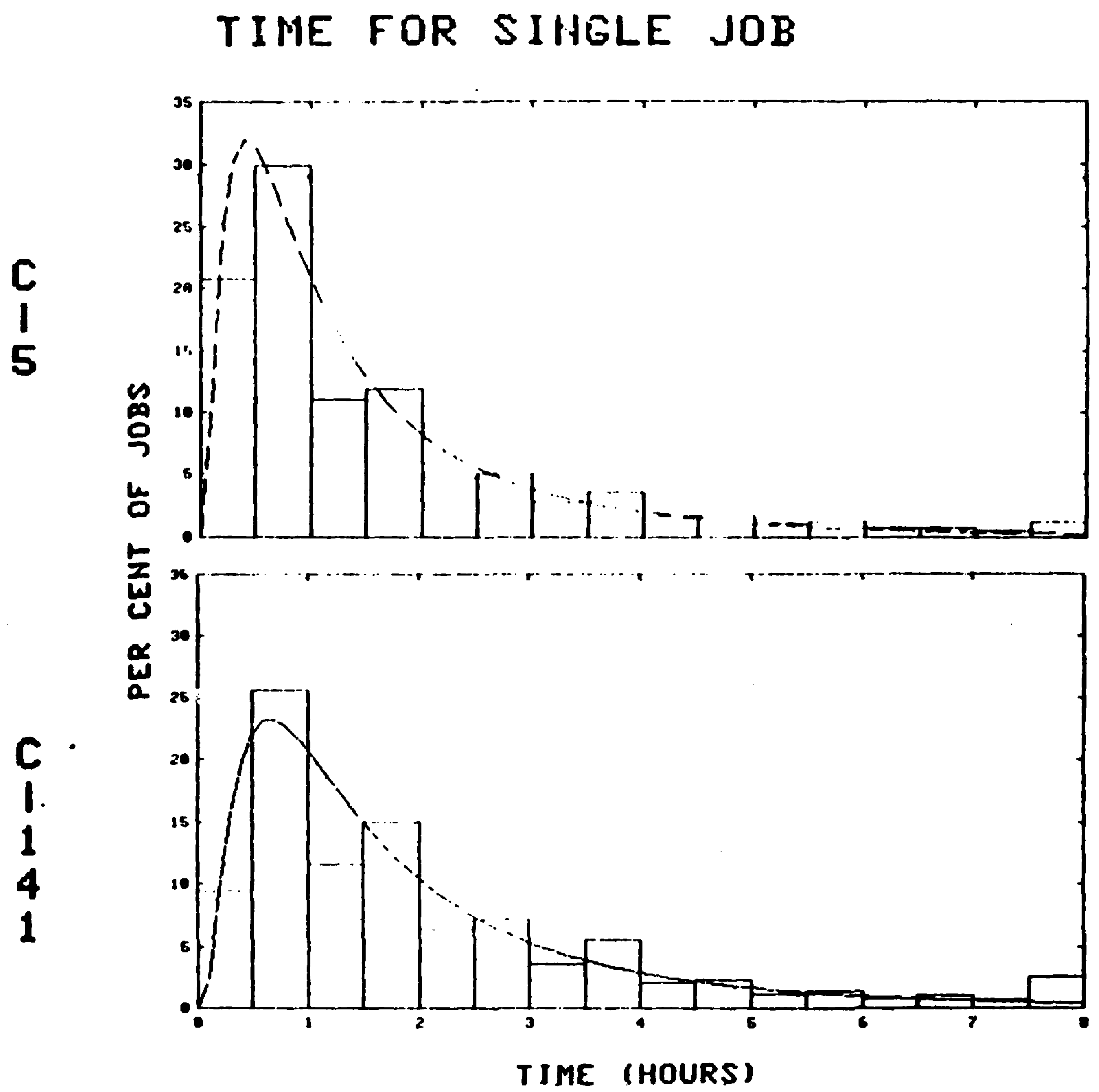
$$\mathrm{MAX}\left\{\frac{T_1 + T_2 + \ldots + T_N}{N^C},\ T_{LONG}\right\}$$

T_I = TIME FOR JOB I

T_{LONG} = TIME FOR LONGEST JOB

N = NUMBER OF MAINTENANCE CREWS

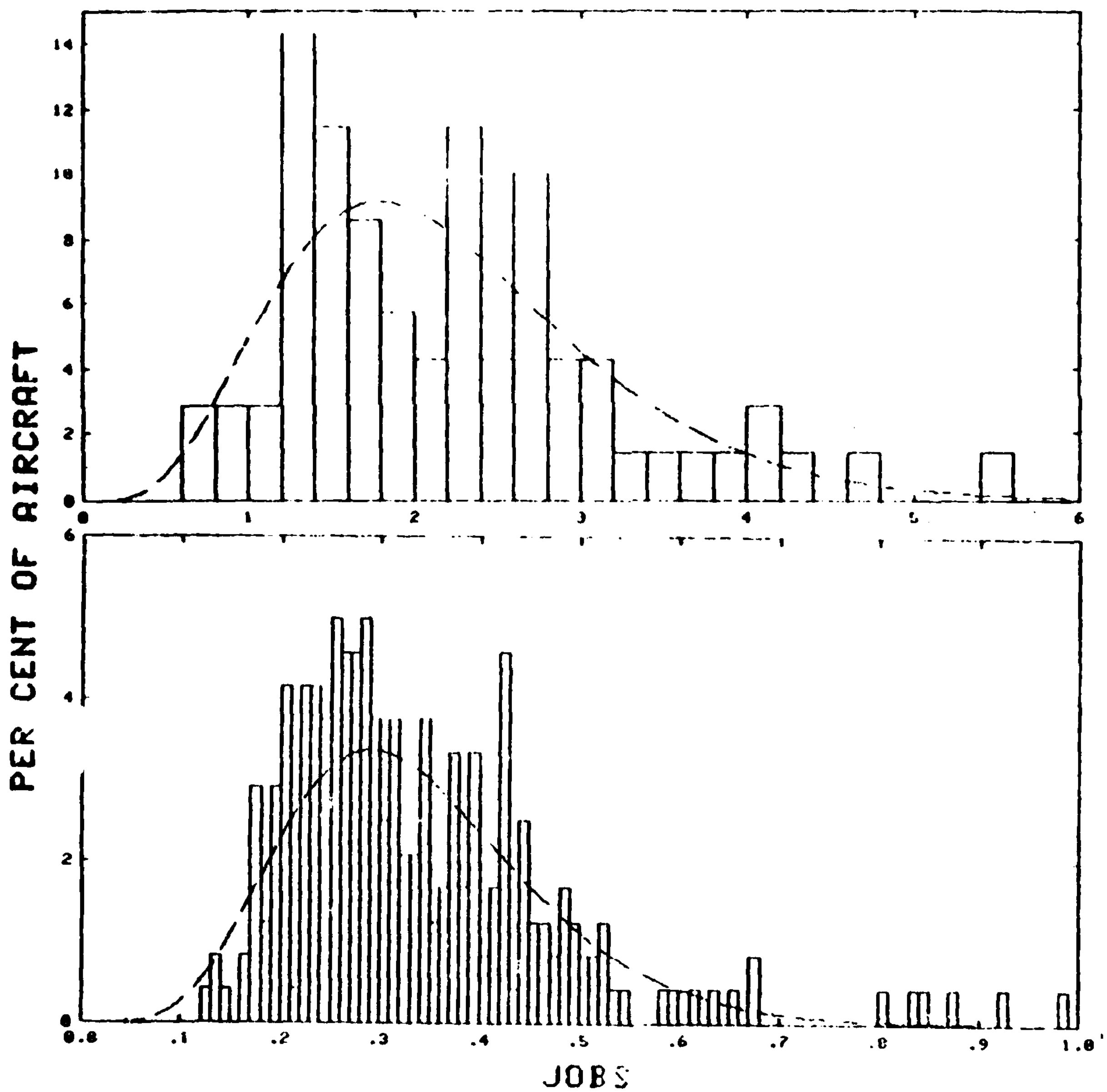
C = CONCURRENCY FACTOR (NOW 0.9)



TIME FOR SINGLE JOB
C-5
C-141
PER CENT OF JOBS
TIME (HOURS)

JOBS PER FLYING HOUR

HOME STATION — MOB — FOB



	HOME STATION	MOB	FOB
C-5		0.193	0.005
C-141		0.031	0.001

UNSCHEDULED MAINTENANCE PER LANDING

MDC SYSTEM
- JULY 79 - JUNE 80
- ABD6DA DATA (BASE LEVEL)

EXTRACTION
- MESL-RELATED DISCREPANCIES
- CONCURRENCIES
- IDLE TIME

SUMMARIES

HOW MUCH?

FLYING TIME
STATION TYPE

HOW LONG?

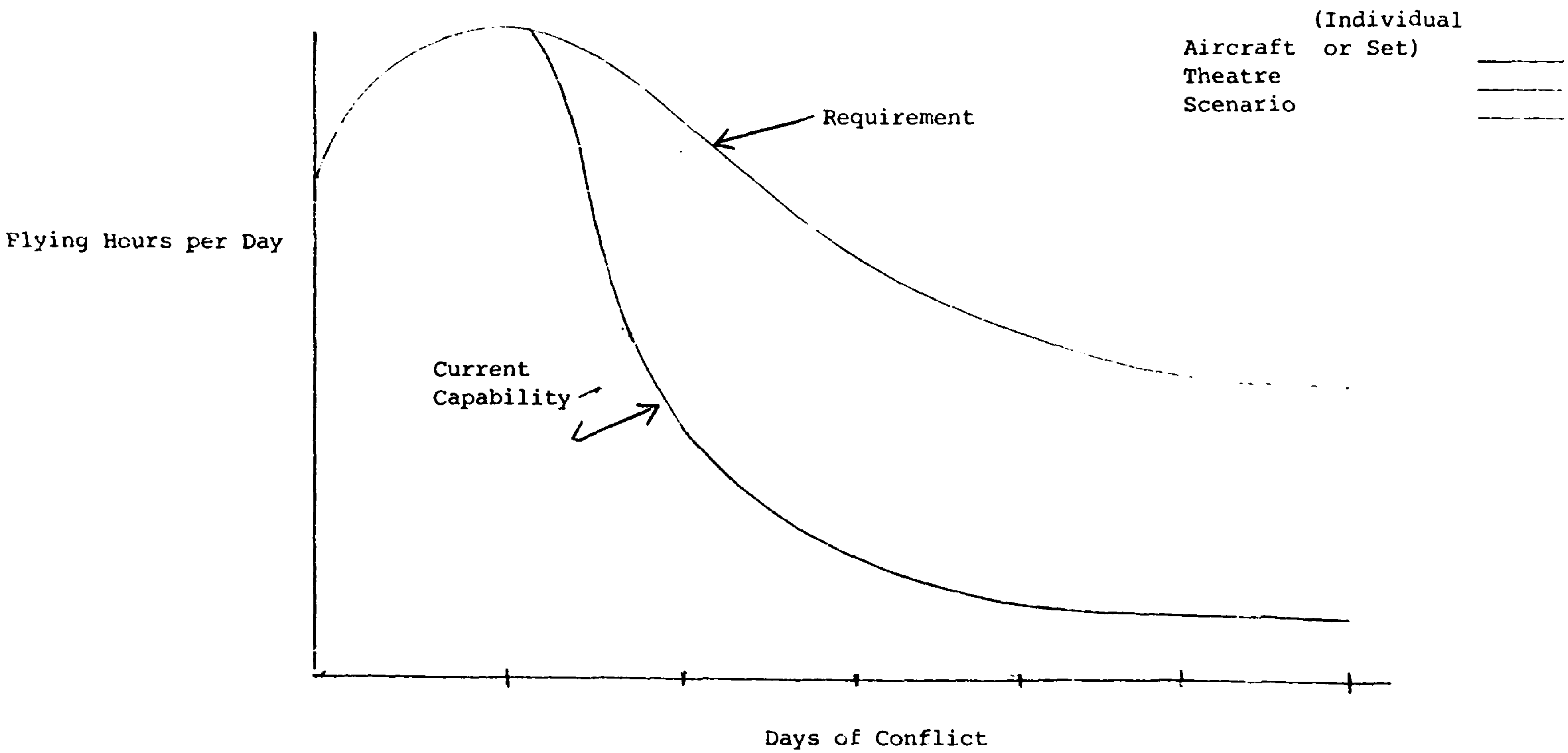
JOB TIMES
PERSONNEL
CONCURRENCY

M-14 LOGISTICS

RESOURCES	FUNCTIONS
TIME	SCHEDULED
	INSPECTIONS
FUEL	FUELING
	HOME STATION TRANSIT
SPARES	"CATCH UP" MAINTENANCE
	ISOCHRONAL INSPECTIONS
PEOPLE	UNSCHEDULED
	MAINTENANCE
	SUPPLY (OFF-STATION)

Figure 1

Hypothetical Requirements and
Capability Chart
Single Logistics Component



Plan (WMP), which can also be translated into sorties or other types of requirements. The requirements are all based upon the USAF War Mobilization Plan (WMP) programmed flying hours for that particular scenario and are consistent with flying hours used for other analyses.

In the aggregate, the requirements line represents the sum of required flying hours for all aircraft in the theatre. For comparability, we also develop an aggregate capability line for the same aircraft/theatre/scenario combination, although aggregate capability is a relatively imprecise term. A key component of the analysis is the construction of an aggregate capability line while preserving the integrity of the individual capability assessments for MDSs, countries, major missions, etc. For example, we show how spares aggregate requirements for the base case are developed through summing across individual MDs.

2. Spares

There is a set of unique capability estimates for each MD and in many cases down to the MDS level. Synergy and LEXY have been developing individual charts showing capability on an MD or MDS basis for major weapons systems. These charts have shown the days of conflict along the abcissa, as in Figure 1, and a flying hour rate (flying hours per aircraft per day) along the ordinate. These charts show the mission requirements levied against each MD and the capability at various funding levels and for various years.

In the spares area, we aggregate the individual capability estimates for the MDs into an aggregate capability for a group of MDs, however specified. This aggregate capability estimate for a group of MDs must preserve the integrity of the individual estimates of the spares capability on an MDS

basis. Therefore, the aggregation process must be done in a way which weighs both requirements and capability appropriately on an MDS basis. Therefore, one level of weighting is by the percent of total flying hour requirements by MD by time period. That is, for a particular time interval (day), we compute the relative percentage allocations of flying hour requirements by MD for that group of aircraft being examined. For example, the base case tactical analysis includes the A-7, A-10, F-4, F-15, F-16, and the F-111. For each of these MDs over the days of the conflict, we have the percentage allocations for individual time intervals. These data provide one basis for weighting the capability estimates.

The second method of weighting is to look at the actual capability profiles by MD, by time period. Therefore, we examine the percent capability to fly the assigned missions for each MD throughout time. These capability profiles are then weighted by mission requirements to develop an aggregate, weighted spares capability by MD, by time period. This aggregate, weighted spares capability by time period can then be displayed against the aggregate requirements for that group of aircraft. The resulting chart is a graphic description of current spares capability (assuming perfect distribution) for tactical air in the European theatre, under the NATO scenario.

For spares, as for other components, it is important to be able to examine different scenarios, theatres, and groups of aircraft. We have designed the spares methodology to allow assessment for any combination of the above to represent a particular capability. We have also developed the methodology to allow for automated integration of the information available from the Overview Model and expert judgment from analysts on the Air Staff. All of the

estimates for capability of spares are developed from the detailed Overview procedure which has been described elsewhere. Therefore, these methods build upon, and aggregate from, detailed estimates of capability by MDS, which in turn are based on individual spare-specific analysis.

3. Petroleum, Oil, and Lubricants (POL)

POL capability is analyzed by individual geopolitical areas. All aircraft at a base or in a region draw their fuel from the stockpile in that area. Fuel is a bulk cargo, difficult to transport and store, particularly on short notice. Consequently, the most meaningful analysis of fuel capability or capacity under wartime conditions is by detailed geographical areas conforming to fuel storage regions. Our procedure is to take individual capability estimates for these areas and aggregate them to a theatre level by scenario.

For the European theatre we examine total European requirements in millions of barrels, by time period, and the capability (again in millions of barrels) in each of the individual countries or areas which would be involved in a European theatre conflict. We can then derive an aggregate percent capability for the European area as measured against aggregate requirements in that area.

It is important, however, only to use this as a device to look at the fuel situation in aggregate compared with other assets. If a more detailed analysis is required, it would be important to return to the lower level of disaggregation because of the distributional problems associated with POL. Also, isolated bases or areas may have a significantly different capability than would be described in the aggregate curve. The methodology is general, and therefore we can look at finer levels of disaggregation if required or

particular groupings which may be important for certain missions.

To develop these individual estimates, we obtained data from HQ USAF/LEYSF, the office responsible for estimating POL capability. We worked closely with their personnel to develop a methodology consistent with their capability estimates.

As we understand it, most of the LEYSF capability estimates are calculated by hand. Data systems relating to fuel do exist, but they are not readily accessible or do not include data in the proper format to extract the precise information required for POM support work. New systems are under development which would help to solve this problem. In the interim, we intend to provide inputs to the automated version of the balanced program methodology developed directly by LEYSF. Later, the automated system could generate outputs which would feed directly into the balanced program model.

4. Munitions

The first step in analyzing munitions is to disaggregate the flying hours or sorties programmed against individual MDSs into major mission types. The three major missions are air-to-air, air-to-ground armor (against mobile targets), and air-to-ground other (against stationary targets). This sortie breakdown can be developed through use of role effect factors (REFs), which distribute total sorties by MDS across major missions for each MDS. Therefore, it is possible to use role effect factors to devise requirement profiles in terms of sorties or flying hours which would represent requirements for munitions relating to these major missions.

The role effect factors are multi-dimensional, and vary over time as new weapons systems are introduced and squadron assignments change. They vary by

theatre, since theatres face different threats, have different types of major missions, and different force structure relative to one another. They also vary over the days of the conflict as the relationship between the air and ground war change. These role effect factors are developed in HQ USAF/XOXFM and are based on information provided by the major commands.

Once we have disaggregated the requirements line into individual major mission areas, we then determine the munition requirements. For example, in the air-to-ground armor area, we identify the major type of munition requirements based on the number of programmed sorties to be flown in that major mission area. We then look at the number of the individual munition types available in that year to fight that particular conflict and indicate the number of days of sustainability for each munition item. We then look at the situation, first without substitutability, and second, with substitution by munition type.

The data and methodology in the air-to-ground munitions area have been developed in close coordination with HQ USAF/XOXFM. The requirements were generated from outputs of their models which are part of the munition requirements process, called the Non-nuclear Consumables Annual Analysis (NCAA). We took direct model runs and outputs already generated by XOXFM and entered them into our system. Unfortunately, since the type of information we needed was not readily accessible, substantial amounts of hand calculation were required. Our hand calculations are appropriate for computerization, since they are simple and involve many repetitions of the same type of arithmetic process. Currently, a direct link is being established between XOXFM model runs and the automated balanced program model.

An Approach to Assessing
the Combat Value of the
European Distribution
System (EDS)

Presen*.d by
Dr. M. B. Berman
The RAND Corporation

Paper Not Included.

For more information, contact the author at:

(213) 393-7846

or write:

The RAND Corporation
1700 Main G
Santa Monica, CA 90406

Modeling Ground Launched Cruise Missile Availability

By: Capt J. Lowell AFTEC/LGL

Capt G. Hoenshell AFTEC/LGY

TITLE SLIDE

I'M CAPT JIM LOWELL FROM THE HQ AFTEC LOGISTICS PROGRAM SUPPORT DIVISION. TODAY'S BRIEFING WILL CENTER AROUND OUR MODELING AND ANALYSIS EFFORTS RELATIVE TO OPERATIONAL TEST AND EVALUATION. I WILL DISCUSS SUCH MODELING AND ANALYSIS IN GENERIC TERMS AND THEN CAPT GARY HOENSHELL FROM OUR LOGISTICS STUDIES AND ANALYSIS DIVISION WILL RELATE OUR GENERIC APPROACH TO THE MODELING EFFORT UNDERWAY FOR THE GROUND LAUNCH CRUISE MISSILE (GLCM).

OVERVIEW

THE FIRST HALF OF THIS BRIEFING IS DESIGNED TO GIVE YOU AN UNDERSTANDING OF HOW WE WITHIN AFTEC/LG VIEW OUR TEST AND EVALUATION ROLE. AN OVERVIEW OF OPERATIONAL TEST AND EVALUATION (OT&E) AND RELATED LOGISTICS ASSESSMENT WILL HOPEFULLY PROVIDE THIS UNDERSTANDING.

THE SECOND PART OF OUR PRESENTATION GIVEN BY GARY WILL ILLUSTRATE THE BENFITS OF SIMULATION MODELING. HE WILL DISCUSS THE DEVELOPMENT AND USE OF A QGERT SIMULATION MODEL OF THE GLCM SYSTEM AND THEN SUMMARIZE.

THE TEST AND EVALUATION CYCLE

DURING THE ACQUISITION CYCLE, FROM THE CONCEPTUAL PHASE THROUGH DEPLOYMENT, THERE IS SOME TEST AND EVALUATION (T&E) BEING CONDUCTED. OUR PRIMARY INTEREST IS IN THE OT&E. HERE WE SHOW GRAPHICALLY THAT OT&E IS MINIMAL AT THE BEGINNING OF THE ACQUISITION PROCESS AND GROWS AS WE GAIN TEST ARTICLES AND INFORMATION. IN LIGHT OF THIS TIME DEPENDENT INCREASE IN THE ABILITY TO TEST, WE MUST CONSIDER CURRENT TRENDS TOWARD EARLIER LOGISTICS ANALYSIS. AS YOU ALL KNOW, THE DEPUTY SECRETARY OF DEFENSE, MR CARLUCCI WROTE A MEMORANDUM DATED 30 APRIL 1981 THAT OUTLINED SEVERAL DEFENSE ACQUISITION IMPROVEMENT INITIATIVES (DAIP). THIS MEMORANDUM AND OTHER FOLLOW-UP MEMORANDA FROM OSD HAVE INCREASED INTEREST IN THE ASSESSMENT OF LOGISTICS SUPPORT AS IT EFFECTS WEAPON SYSTEMS READINESS AND SUSTAINABILITY. OUR EXPERIENCE WITH ANALYSIS OF THIS NATURE, AT A POINT IN TIME WHEN HARD DATA IS MINIMAL AT BEST, HAS LED US TO A SIMULATION MODELING APPROACH TO PROVIDE INFORMATION FOR DECISION MAKING. IN LIGHT OF DAIP, WE DO NOT CONTEND THAT AFTEC BE THE RESPONSIBLE AGENCY FOR THE CONDUCT OF EARLY LOGISTICS ASSESSMENT. WE DO, HOWEVER, SUPPORT SUCH AN APPROACH AND WOULD BE WILLING PARTICIPANTS IN ANY EFFORT TO IMPROVE THE VISIBILITY OF LOGISTICS SUPPORT.

WHY USE ANALYSIS

I MENTIONED OUR EXPERIENCE WITH IMMATURE SYSTEMS. HERE WE LIST REASONS FOR ANALYSIS. FOR THE MOST PART WE COULD SPECIFY SIMULATION MODELING AS THE ANALYSTS TOOL. AS YOU CAN SEE, THERE ARE SEVERAL CONSTRAINTS WE MUST OPERATE UNDER WHEN CONDUCTING OT&E. WE NEVER HAVE AS MANY TEST ARTICLES AS WE WOULD LIKE. SUPPORT EQUIPMENT AND TECHNICAL DATA ARE NEVER AVAILABLE AND IN GENERAL WE ARE LACKING A TOTAL SUPPORT SYSTEM TO PUT OUR HANDS ON. I COULD GO ON FOREVER LISTING PROBLEMS, BUT IT MAKES MORE SENSE TO TALK ABOUT A SOLUTION TO OUR PROBLEMS. THAT SOLUTION IS MODELING A TOTAL SYSTEM AND THROUGH SIMULATION, ANALYZING AND EVALUATING THE INTERACTION OF ALL SYSTEM VARIABLES. WE AT AFTEC CALL THIS OPERATIONAL SUITABILITY EVALUATION.

BEFORE TALKING ABOUT OPERATIONAL SUITABILITY, I'D LIKE TO SHARE AN IDEA WITH YOU.

MR WILLOUGHBY, DEPUTY CHIEF OF NAVAL MATERIAL FOR RELIABILITY, MAINTAINABILITY, AND QUALITY ASSURANCE TALKED TO THE INSTITUTE OF ENVIRONMENTAL SCIENCES LAST SEPTEMBER. ONE OF THE POINTS HE STRIVED TO GET ACROSS DURING HIS PRESENTATION WAS THAT PARTS SCREENING GIVES VISIBILITY TO THE MANUFACTURING PROCESS. AND THIS VISIBILITY PROVIDES AN OPPORTUNITY TO INCREASE BOTH QUALITY AND PRODUCTION.

I THINK SIMULATION MODELING GIVES THE LOGISTICIAN THIS KIND OF VISIBILITY FOR SYSTEM LOGISTICS SUPPORT. AND THE VISIBILITY WE GAIN TROUGH MODEL DEVELOPMENT CAN IMPROVE LOGISTICS SUPPORT AND INCREASE WEAPON SYSTEM READINESS AND SUSTAINABILITY. VISIBILITY IS INCREASED WITH INTENSE EVALUATION OF OPERATIONAL SUITABILITY.

OPERATIONAL SUITABILITY DEFINITION

IN REALITY, THERE IS NO DIFFERENCE BETWEEN OPERATIONAL SUITABILITY AND WHAT IS BEING TERMED HERE AS LOGISTICS CAPABILITY ASSESSMENT. OPS SUITABILITY IS DEFINED AS THE ABILITY TO SUCCESSFULLY MAINTAIN AND SUPPORT A SYSTEM IN ITS INTENDED OPERATIONAL ENVIRONMENT. OPS SUITABILITY IS MADE UP OF SEVERAL ELEMENTS OF LOGISTICS AS SHOWN HERE.

SUITABILITY ELEMENT INTERACTION

THIS IS A MORE DESCRIPTIVE REPRESENTATION OF THE ELEMENTS OF OPERATIONAL SUITABILITY WITH AN OVERLAY SHOWING THAT THE INFLUENCE OF THE SYSTEMS OPERATIONAL AND MAINTENANCE CONCEPT MUST ALSO BE CONSIDERED IN EVALUATION. AS YOU CAN SEE, THIS TOTAL SYSTEM VIEW LENDS ITSELF TO MODELING. IN FACT, MORE SPECIFICALLY, TO DATE WE HAVE EMPLOYED NETWORK MODELING FOR OPERATIONAL SUITABILITY EVALUATIONS. WITH NETWORK MODELS WE CAN BETTER UNDERSTAND THE INTERRELATIONSHIP BETWEEN THE INDIVIDUAL LOGISTICS ELEMENTS AS THEY ARE CONSTRAINED BY THE OPERATIONAL AND MAINTENANCE CONCEPTS. WE CAN PERFORM SENSITIVITY ANALYSIS TO DETERMINE THE EFFECT EACH ELEMENT HAS ON AVAILABILITY - OUR PRIMARY MEASURE OF EFFECTIVENESS, WE CAN ALSO RELATE THESE ELEMENTS TO BROADER MEASURES SUCH AS READINESS AND SUSTAINABILITY.

T&E PROCESS

LET'S REVISIT SOME OF THE SUBJECTS I'VE TALKED ABOUT TO PUT IT ALL TOGETHER. AS THE BASIS OF AN ANALYSIS, WE HAVE THE WEAPON SYSTEMS USER REQUIREMENTS AND CONCEPTS OF OPERATION AND MAINTENANCE. WE THEN DETERMINE HOW WE CAN BEST DETERMINE HOW WELL THE WEAPON SYSTEM MEETS THESE NEEDS AND DEVELOP A TEST PLAN. AS PART OF THE TEST PLANNING PHASE, WE WILL LOOK AT CRITICAL ISSUES AND TEST OBJECTIVES TO DETERMINE THE METHOD OF ANALYSIS. WE HAVE FOUND THAT MODEL DEVELOPMENT DURING THIS PHASE IS VERY BENEFICIAL IN THAT SUCH A DEVELOPMENT PROCESS EDUCATES THE ANALYST. AS HE BEGINS MODEL DEVELOPMENT, HE LEARNS THE INTRICACIES OF THE SYSTEM AND THE CONCEPTS UNDER WHICH THE SYSTEM OPERATES. AS HE BECOMES AN EXPERT ON THE SYSTEM, HE STARTS RECOGNIZING INEFFICIENCIES AND POSSIBLY ERRORS IN THE SYSTEM PLANS AND CONCEPTS. THE ANALYST CAN BRING THESE TO THE ATTENTION OF THE PROPER ORGANIZATION AND OFTEN RESOLVE PROBLEMS BEFORE THEY HAVE A

DETRIMENTAL EFFECT ON SYSTEM DEVELOPMENT.

ANOTHER AREA IN WHICH THE ANALYST BECOMES EXPERT IS THAT OF DATA GATHERING. HERE HE MUST MASTER TECHNIQUES SUCH AS COMPARABILITY ANALYSIS, DERATING OF CONTRACTOR ESTIMATES AND PERSONAL INTERVIEW. THROUGH A COMBINATION OF THESE TECHNIQUES HE IS ABLE TO CONSTRUCT A DATA BASE TO ESTIMATE SYSTEM PERFORMANCE. OFTEN IN HIS QUEST FOR INFORMATION, THE ANALYST WILL FORCE OTHERS TO TAKE A CLOSER LOOK AT THEIR SPECIFIC AREA OF INTEREST AND THIS CLOSER LOOK CAN LEAD TO BETTER PLANS AND REQUIREMENTS.

IN MANY INSTANCES DEVELOPMENT OF A MODEL HAS HAD CONSIDERABLE EFFECT ON A PROGRAM LONG BEFORE ANY SIMULATION ANALYSIS WAS ACCOMPLISHED.

REQUIREMENTS-LOGISTICS EVALUATIONS

EVENTUALLY THE MODEL WILL BE USED TO AID IN THE PROCESS SHOWN HERE. WE MUST BE CAPABLE OF DETERMINING NOT ONLY THE PRESENT SUITABILITY OF A SYSTEM, BUT ALSO BE ABLE TO PROJECT THE SUITABILITY OF THE MATURE SYSTEM. IN THE INTERIM WE STRIVE TO IMPROVE THE SYSTEM THROUGH THE IDENTIFICATION AND CORRECTION OF DEFICIENCIES. SIMULATION IS OFTEN USED HERE TO EVALUATE THE IMPACT OF DEFICIENCIES ON OVERALL SYSTEM CAPABILITY AND ALSO TO EVALUATE PROPOSED FIXES. THROUGH AN ITERATIVE PROCESS, INFORMATION OBTAINED WITH SIMULATION WILL HELP US CONSTRUCT A BETTER LOGISTICS SUPPORT STRUCTURE THAN WE WOULD HAVE HAD WITHOUT THE INSIGHT GAINED FROM A MODELING EFFORT.

DEFICIENCIES

THIS IS HOW WE VIEW THE DEFICIENCY PROCESS. AT PRESENT WE HAVE CONSIDERABLE CONTROL OVER THE PROCESS UP TO AND INCLUDING PRIORITIZATION. IN THE TEST ENVIRONMENT WE DISCOVER, SCREEN, AND REPORT DEFICIENCIES. THEN THROUGH SIMULATION ANALYSIS WE DETERMINE THE COST OF A DEFICIENCY TO READINESS AND THE PAYOFF OF FIXING THE DEFICIENCY. THIS ANALYSIS ENABLES US TO PRIORITIZE THE LOGISTICS-RELATED DEFICIENCIES. ALTHOUGH WE CAN EVALUATE THROUGH SIMULATION, THE EFFECT FIXING A DEFICIENCY HAS ON, SAY SORTIE RATE, WE HAVE NO CONTROL OVER FUNDING AND ACTUAL FIXING.

WE ARE ATTEMPTING TO CLOSE THIS LOOP AND HOPE THAT THROUGH IMPLEMENTATION OF THE CARLUCCI INITIATIVES, RESPECIALLY THE INCREASED CONCERN OVER EARLY LOGISTICS ASSESSMENTS, SIMULATION ANALYSIS OF THE TYPE WE DO WILL HAVE MORE INFLUENCE ON PROGRAM DECISIONS.

A FUNDAMENTAL TRUTH

HISTORICALLY, WE HAVE PLACED SYSTEMS IN THE FIELD WITHOUT ADEQUATE LOGISTICS SUPPORT. THIS LACK OF LOGISTICS SUPPORT WHICH MANIFESTS ITSELF AS POOR SYSTEM READINESS AND SUSTAINABILITY. WE WANT TO TURN THIS AROUND. AS MR. AUGUSTINE, CHAIRMAN OF THE DEFENSE SCIENCE BOARD, STATED IN THE FEBRUARY 1982 GOVERNMENT EXECUTIVE; "ONCE HIGH INHERENT AVAILABILITY (PRINCIPALLY, RELIABILITY) HAS BEEN DESIGNED INTO A SYSTEM...CAPABILITY STILL CAN BE ERODED BY INADEQUATE PROVISION FOR LOGISTICS SUPPORT...." WE LOGISTICIANS ARE THE ONLY FORCE IN THE ACQUISITION PROCESS THAT CAN IMPROVE THE VISIBILITY LOGISTICS SUPPORT ISSUES. WE CAN DO THIS THROUGH GOOD ANALYSIS USING SIMULATION MODELING. WE CAN MAKE THE SYSTEM AND THE SUPPORT BETTER. NOW GARY WILL ILLUSTRATE HOW WE INTEND TO MAKE IT WORK WITH THE GROUND LAUNCH CRUISE MISSILE AVAILABILITY SIMULATION MODEL.

PICTURE OF GLCM SYSTEM

FOR THOSE OF YOU WHO ARE NOT FAMILIAR WITH THE GLCM WEAPON SYSTEM, THIS PICTURE SHOWS ITS THREE MAJOR SYSTEMS; THE LAUNCH CONTROL CENTER (LCC), THE TRANSPORTER ERECTOR LAUNCHER (TEL), AND TOMAHAWK MISSILE. EACH TEL IS DESIGNED TO HOLD FOUR MISSILES. THE BASIC CONFIGURATION IS THE FLIGHT WHICH CONSISTS OF 16 MISSILES CARRIED ON FOUR TELS EACH CONNECTED TO TWO LCCS (THE SECOND LCC PROVIDES REDUNDANCY).

GLCM PROGRAM BACKGROUND

THE GLCM PROGRAM IS PRESENTLY JUST BEGINNING ITS COMBINED OPERATIONAL TEST AND EVALUATION WHICH IS BEING CONDUCTED AT DUGWAY PROVING GROUNDS, IN UTAH. THIS INITIAL TESTING WILL CONTINUE THROUGH MARCH OF 83. IN MAY OF 83, THE AIR FORCE SYSTEMS ACQUISITION REVIEW COUNCIL WILL MEET TO ASSESS THE STATUS OF THE TOTAL GLCM PROGRAM WITH EMPHASIS ON THE RESULTS OF THIS INITIAL TESTING. PHASE ONE OF FOLLOW-ON TESTING WILL BEGIN SOON AFTER OUR INITIAL TESTING AND CONTINUE THROUGH JUNE OF 84. ALL OF THIS TESTING IS LEADING TO THE MOST CONSTANT DATE IN THE GLCM PROGRAM, IOC IN DECEMBER OF 83.

SINCE MY INVOLVEMENT IN THE GLCM PROGRAM OVER THE PAST YEAR AND A HALF, I WOULD HAVE TO CATEGORIZE THE PROGRAM AS A "FAST MOVING TRAIN", TRYING TO "MAKE UP" LOST TIME, TO MEET ITS SCHEDULED ARRIVAL (IOC). ALTHOUGH THE TOMAHAWK MISSILE HAS BEEN AROUND FOR QUITE SOME TIME, THE TOTAL SYSTEM (LCCS AND TELS) AND ITS INTEGRATION IS STILL IN DEVELOPMENT. AS INDEPENDENT TESTERS, AFTEC IS TASKED TO TEST AND EVALUATE OPERATIONAL SYSTEMS. THE GLCM PROGRAM IS STILL A LONG WAY FROM BECOMING A COMPLETE OPERATIONAL SYSTEM, EVEN THOUGH IOC IS DEC 83. I'LL BE DISCUSSING SOME OF THE SYSTEM SHORTAGES LATER.

IT'S BECAUSE OF THESE SHORTAGES THAT WE RELY HEAVILY ON MODELING. SINCE A COMPLETE SYSTEM IS NOT ALWAYS AVAILABLE TO TEST, WE USE MODELING TO PROJECT SYSTEM CAPABILITY. DURING THIS PROCESS WE USE MODELING TO IDENTIFY PROBLEM AREAS AND RECOMMEND ENHANCEMENTS.

GLCM TEST LIMITATIONS

TO GIVE YOU AN INDICATION OF SOME OF THE TEST LIMITATIONS WE FACE, I'VE LISTED HERE A COMPARISON OF WHAT WE HAVE TO TEST WITH VERSUS WHAT WE WILL SEE IN A MATURE OPERATIONAL ENVIRONMENT. AS YOU CAN SEE, IT'S VERY DIFFICULT TO HAVE A REPRESENTATIVE TEST OF A COMPLETE WEAPON SYSTEM WITH LIMITATIONS LIKE THESE.

SUITABILITY ELEMENT INTERACTION

JIM SHOWED YOU A SLIDE VERY SIMILAR TO THIS BUT I'VE ADDED SOME COLOR CODING IN CERTAIN AREAS TO SHOW WHERE WE STAND TODAY REGARDING INFORMATION AND HARDWARE NECESSARY TO CONDUCT A COMPLETE OPERATIONAL SUITABILITY EVALUATION. ONE ELEMENT I'D LIKE TO FOCUS YOUR ATTENTION TO IS THE YELLOW CODED SOC. THE SOC, WHICH INCLUDES THE MAINTENANCE

CONCEPT, REQUIRES CONTINUOUS RETHINKING AND UPDATING BY THE USER. IN REGARDS TO THE GLCM PROGRAM, THE SYSTEM HAS CHANGED AT SUCH A RAPID PACE THAT THE PUBLISHED GLCM SOC OF OCT 81 IS NO LONGER VALID AND THERE HAS BEEN NO UPDATES. .

MODEL ANALYSIS OBJECTIVES

THE LAST TWO SLIDES SHOULD GIVE YOU THE IMPRESSION THAT WE ARE TESTING AND EVALUATING A SYSTEM THAT IS NOT TOTALLY DEVELOPED OR IN SOME CASES, DEFINED. THESE LIMITATIONS DRIVE US TO RELY MORE HEAVILY ON OUR MODELING ANALYSIS.

THE PRIME OBJECTIVE IN OUR SUITABILITY EVALUATION IS TO ASSESS A MATURE GLCM WEAPON SYSTEM'S AVAILABILITY; THAT IS, HOW MANY LAUNCHABLE MISSILES WILL A GLCM WING BE ABLE TO LAUNCH, AT A RANDOM POINT IN TIME, EXCLUDING THREAT. IN DOING THIS ANALYSIS, WE CONCENTRATE ON MODELING THE ELEMENTS THAT MAKE UP AVAILABILITY AS JIM AND I DESCRIBED EARLIER. NOT ONLY WILL WE ASSESS AVAILABILITY WITH THE MODEL, BUT WE WILL ATTEMPT TO IDENTIFY ANY PROBLEM AREAS THAT ARE IMPACTING OUR ABILITY TO ACHIEVE THE REQUIRED AVAILABILITY.

GLCM SYSTEM FLOW

HERE WE SHOW THE MAJOR ACTIVITIES THAT ARE ASSOCIATED WITH THE GLCM SYSTEM WHICH MUST BE INCLUDED IN OUR Q-GERT AVAILABILITY MODEL. EACH OF THESE ACTIVITIES REQUIRE MUCH DETAILED INFORMATION FROM THE USER IN ORDER TO ACCURATELY PORTRAY THE PROPER FLOW OF RESOURCES THROUGH THE SYSTEM. WE'VE BEEN FORCED TO INITIATE PERIODIC MEETINGS WITH GD, JCMPO, AND THE TAF TO OBTAIN THE MOST RECENT SYSTEM SCENARIOS. THUS OUR MODELING NEEDS HAVE CAUSED THE USER TO RE-EVALUATE THEIR PLANS AND REQUIREMENTS FORCING THEM TO LOOK CLOSER AT DETAILED DECISIONS THAT MUST BE MADE.

USE OF Q-GERT MODELING TOOL

FOR THOSE OF YOU WHO ARE INTERESTED IN SIMULATION LANGUAGES, OUR AVAILABILITY MODEL IS IN Q-GERT WHICH IS A FORTRAN BASED LANGUAGE. IT SATISFIES THE NEED FOR A NETWORK APPROACH TO MODELING THE GLCM SYSTEM THAT INVOLVES PROCESSES AND ACTIVITIES. THE CHANGES IN THE GLCM PROGRAM HAS CAUSED MANY MODEL CHANGES BUT THE Q-GERT LANGUAGE HAS HANDLED THESE CHANGES WITH LITTLE PROBLEM.

GLCM AVAILABILITY MODEL ANALYSIS APPROACH

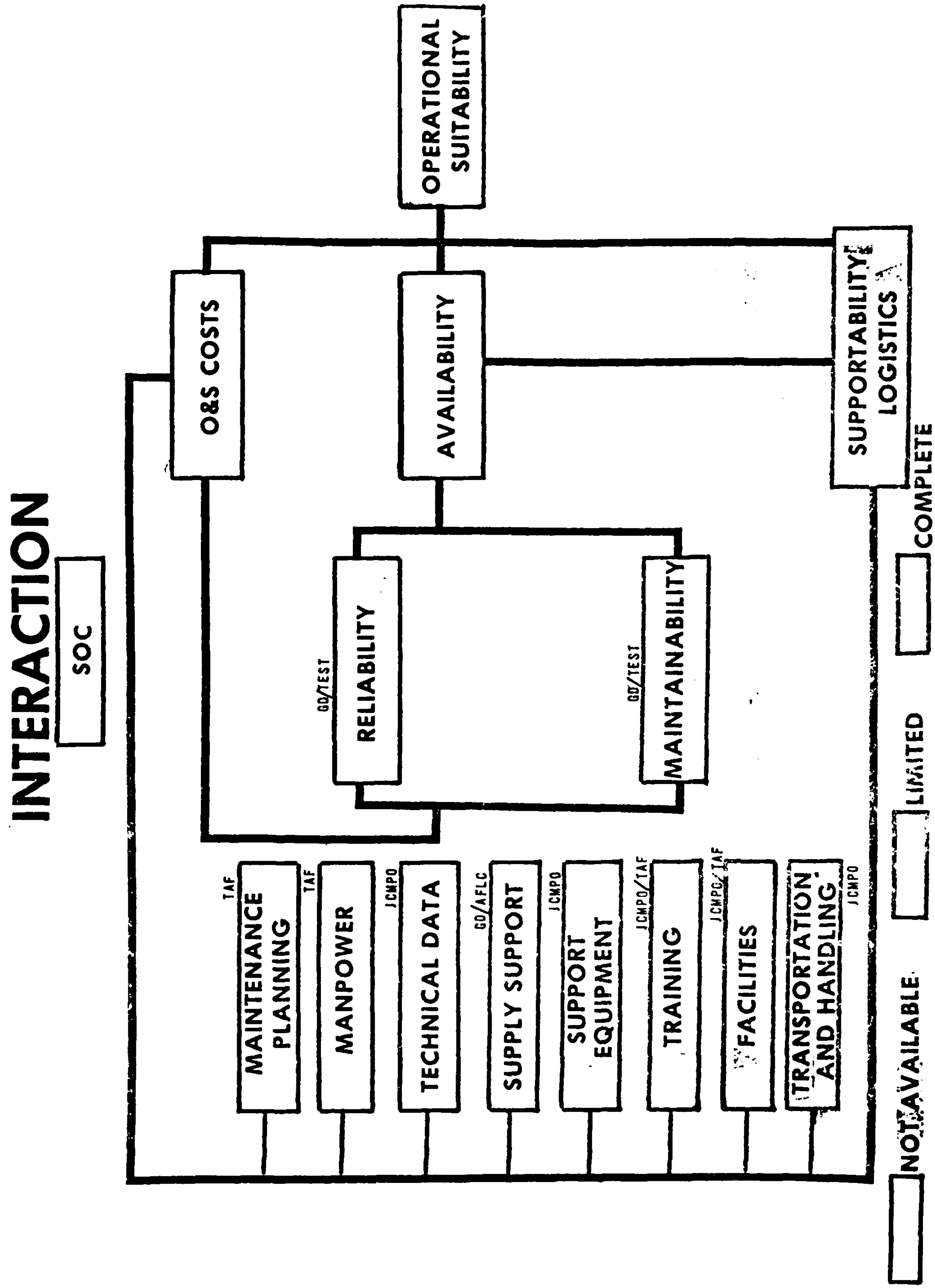
WITH THE TEST LIMITATIONS I DISCUSSED EARLIER, OUR FIRST BASELINE WILL BE BASED MOSTLY ON CONTRACTOR PREDICTION AND ESTIMATED DATA. WE'LL USE THIS BASELINE TO CONDUCT OUR INITIAL SENSITIVITY STUDY TO DETERMINE WHAT SYSTEM VARIABLES AFFECT MISSILE AVAILABILITY MOST. AS R&M DATA BECOME AVAILABLE FROM THE TESTING AT DUGWAY, WE'LL ANALYZE AND INCORPORATE THE APPROPRIATE CHANGES. BY THE SPRING IN 83, WE WILL DO OUR FINAL ANALYSIS FOR THE IOT&E TEST REPORT, PROJECTING AVAILABILITY FOR A MATURE GLCM WING.

MODELING IDENTIFIES MAJOR CONCERNS

EARLIER I DISCUSSED OUR OBJECTIVE IN MODELING; TO ASSESS GLCM AVAILABILITY. IN ACCOMPLISHING THAT OBJECTIVE WE LEARN AND IDENTIFY PROBLEM AREAS IN THE SYSTEM THAT HAVE A LARGE IMPACT ON AVAILABILITY. FOR THE GLCM SYSTEM THREE AREAS STAND OUT AS POTENTIAL CONCERNS IMPACTING ITS AVAILABILITY. THESE ARE: (1) DORMANT RELIABILITY, (2) DIAGNOSTIC CAPABILITY, AND (3) THE INSPECTION CYCLE. DORMANT RELIABILITY IS A CONCERN BECAUSE OF THE AMOUNT OF TIME THE LCCS, TELS AND MISSILES REMAIN IN EXTENDED STORAGE. THIS TOPIC WAS DISCUSSED IN DETAIL IN AN EARLIER BRIEFING. THE CONCERN OVER DIAGNOSTICS CENTER ON THE DEVELOPMENT PROBLEMS ASSOCIATED WITH THE SOFTWARE. THIS CAN HAVE A TREMENDOUS IMPACT ON MANPOWER, SE, AND TOS IF IT DOESN'T PERFORM AS REQUIRED. AS FOR THE INSPECTION CYCLE, ITS FREQUENCY WILL BE A BIG FACTOR IN DETERMINING WORKLOAD.

SUMMARY

TODAY JIM AND I HAVE TRIED TO GIVE YOU AN UNDERSTANDING OF HOW WE WITHIN AFTEC/LG VIEW OUR TEST AND EVALUATION ROLE. I'VE USED THE GLCM PROGRAM TO DEMONSTRATE TESTING PROBLEMS AND HOW WE USE MODELING TO SOLVE THEM. THE GLCM IS A GOOD EXAMPLE SINCE IT IS A PROGRAM THAT WE'RE PRESENTLY TESTING EVEN THOUGH IT IS STILL IN DEVELOPMENT. THE GLCM PROGRAM HAS MANY TEST LIMITATIONS THAT MAKES A COMPLETE SUITABILITY EVALUATION DIFFICULT. BUT TEST SHORTCOMINGS CAN BE OVERCOME BY USING SYSTEM MODELS. FOR THE GLCM PROGRAM WE HAVE DEVELOPED AN AVAILABILITY MODEL WHICH WE WILL USE TO PROJECT SYSTEM CAPABILITY. WE'LL ALSO USE THE MODEL TO IDENTIFY PROBLEM AREAS EARLY SO THAT THEY MAY BE CORRECTED BEFORE THEY HAVE A DETRIMENTAL EFFECT ON OPERATIONAL AVAILABILITY.


INTERACTION
SOC
OPERATIONAL SUITABILITY
O&S COSTS
AVAILABILITY
SUPPORTABILITY LOGISTICS
GO/TEST
RELIABILITY
GO/TEST
MAINTAINABILITY
TAF
MAINTENANCE PLANNING
TAF
MANPOWER
JCMPO
TECHNICAL DATA
GO/AFLC
SUPPLY SUPPORT
JCMPO
SUPPORT EQUIPMENT
JCMPO/TAF
TRAINING
JCMPO/TAF
FACILITIES
JCMPO
TRANSPORTATION AND HANDLING
COMPLETE
LIMITED
NOT AVAILABLE

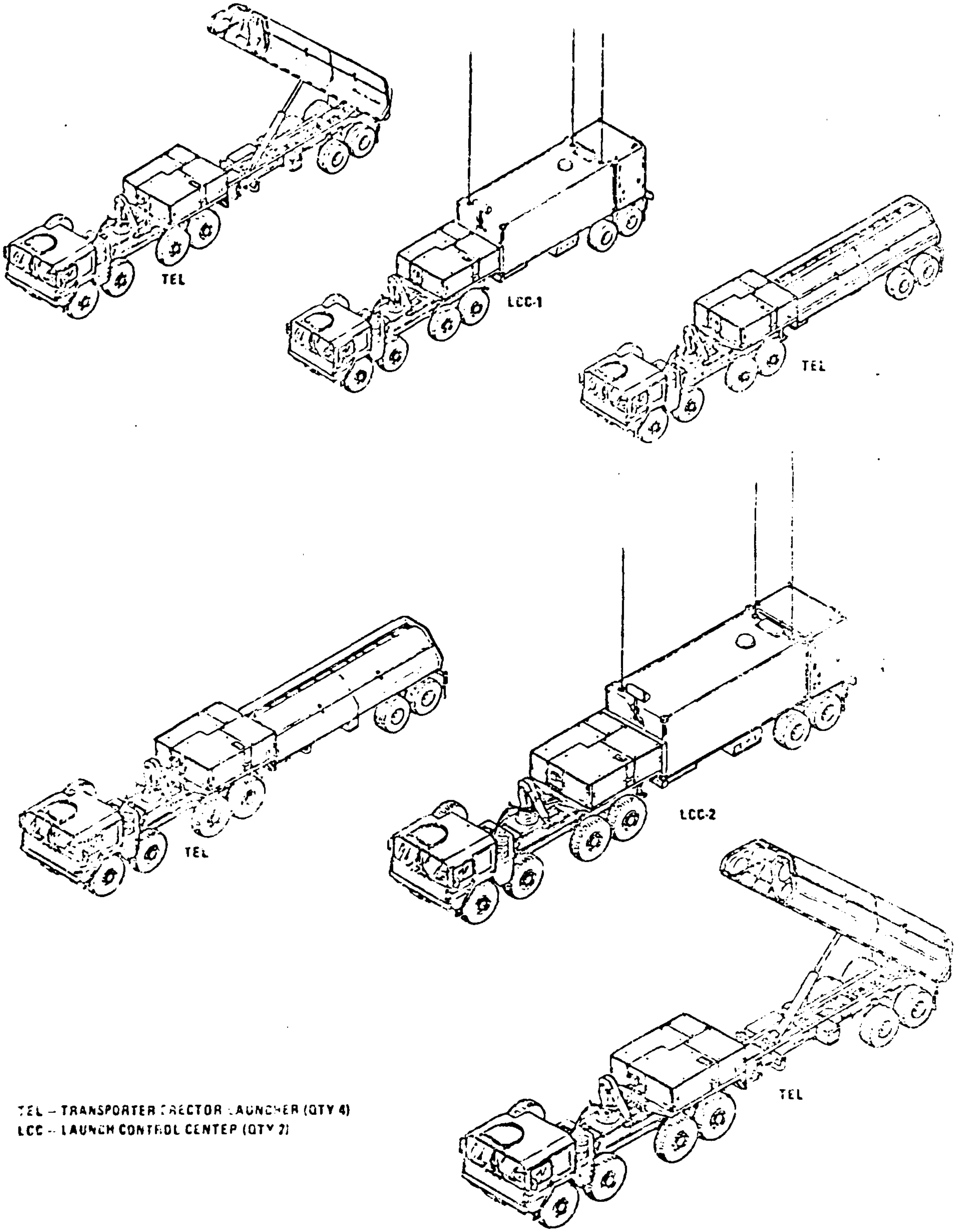
GLCM TEST LIMITATIONS

TEST ENVIRONMENT	OPERATIONAL ENVIRONMENT
1. 1 FLIGHT (LATE IN TEST)	1. 3 TO 6 FLIGHTS
2. CONTRACTOR/BLUE SUIT MAINTENANCE	2. BLUESUIT MAINTENANCE
3. HIGHLY SKILLED AND SPECIALIZED TEST TEAM	3. LESS SKILLED MAINTENANCE PERSONNEL
4. 50% SE AND LIMITED FACILITIES	4. TOTAL SE AND FACILITIES
5. SPARES WITH PRIORITY SUPPORT	5. NORMAL BASE/DEPOT SUPPLY SUPPORT
6. IMMATURE T.O.s	6. MATURE T.O.s
7. PRE PRODUCTION LCC s, TELs, AND MISSILES	7. PRODUCTION LCCs, TELs, AND MISSILES
8. DEVELOPMENT SOFTWARE	8. PRODUCTION SOFTWARE

GLCM PROGRAM BACKGROUND

- SCHEDULE
  - IOT&E (FEB 82- MAR 83)
  - AFSARC (MAY 83)
  - FOT&E (I) (APR 83- JUNE 84)
  - IOC (DEC 83)
- GLCM- FAST MOVING TRAIN
  - SYSTEM STILL IN DEVELOPMENT
  - AFTEC TASK TO T&E OPERATIONAL SYSTEMS
- RELY HEAVILY ON MODELING
  - PROJECT SYSTEM CAPABILITY
  - IDENTIFY DEFICIENCIES/ENHANCEMENTS

BGM-109
GROUND LAUNCHED CRUISE MISSILE



TEL – TRANSPORTER ERECTOR LAUNCHER (QTY 4)
LCC – LAUNCH CONTROL CENTER (QTY 2)

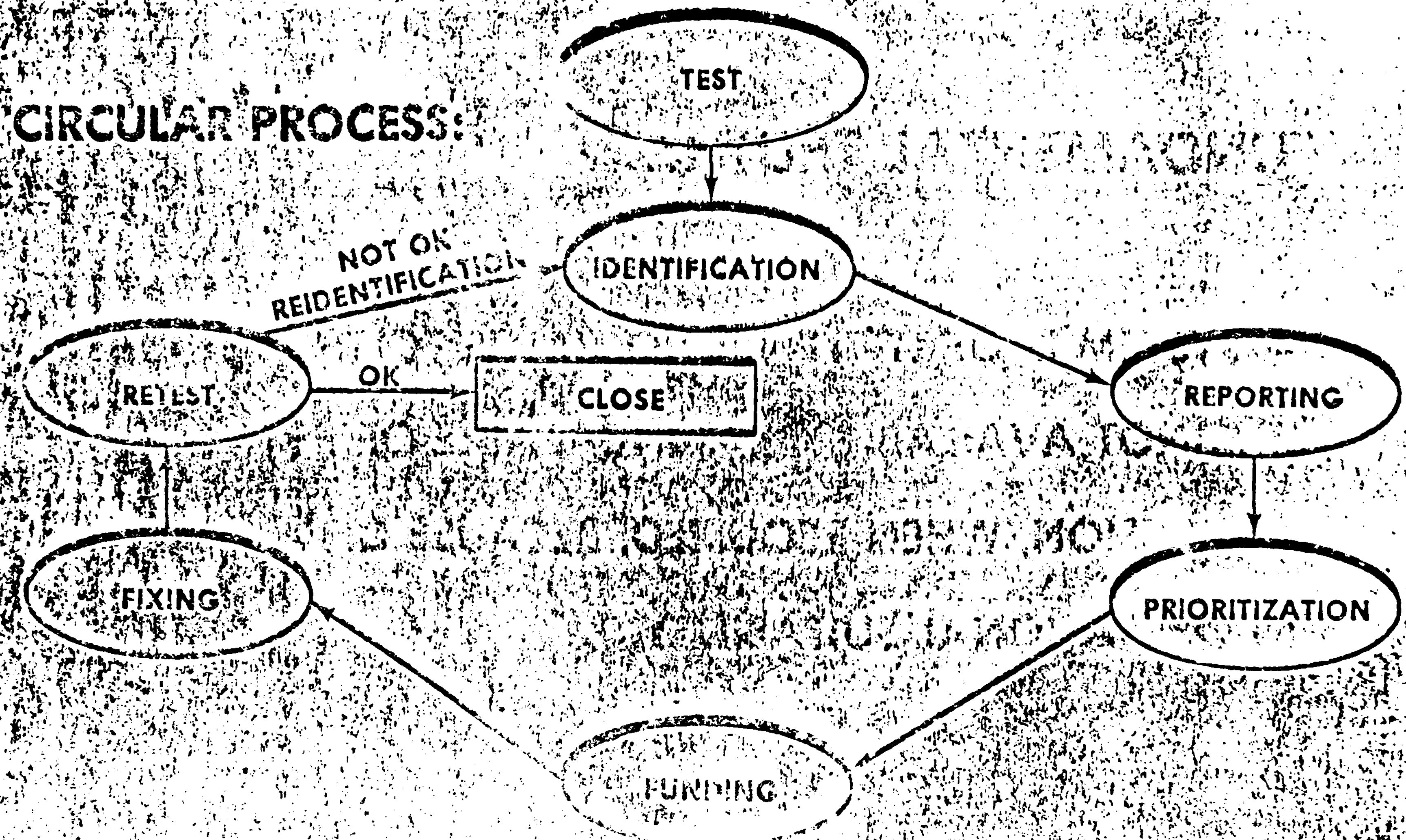
GLCM Flight

A FUNDAMENTAL TRUTH...

A SYSTEM IS OF LITTLE OR NO VALUE TO THE USER IF IT IS NOT AVAILABLE OR IS INCAPABLE OF PERFORMING ITS MISSION, WHEN REQUIRED, BECAUSE OF DEFICIENCIES IN OPERATIONAL SUITABILITY.

DEFICIENCIES

CIRCULAR PROCESS:

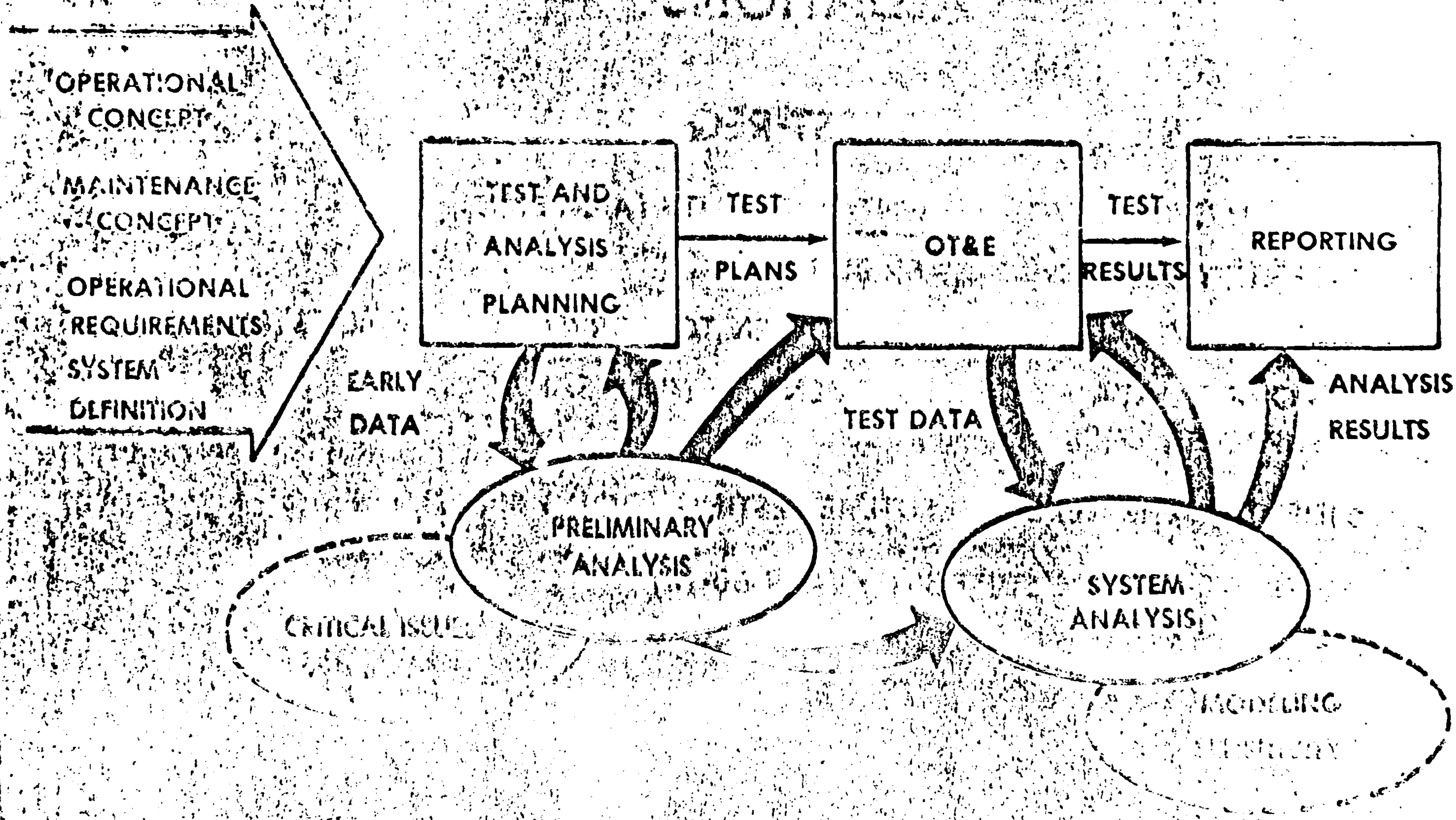


REQUIREMENTS - LOGISTICS EVALUATIONS

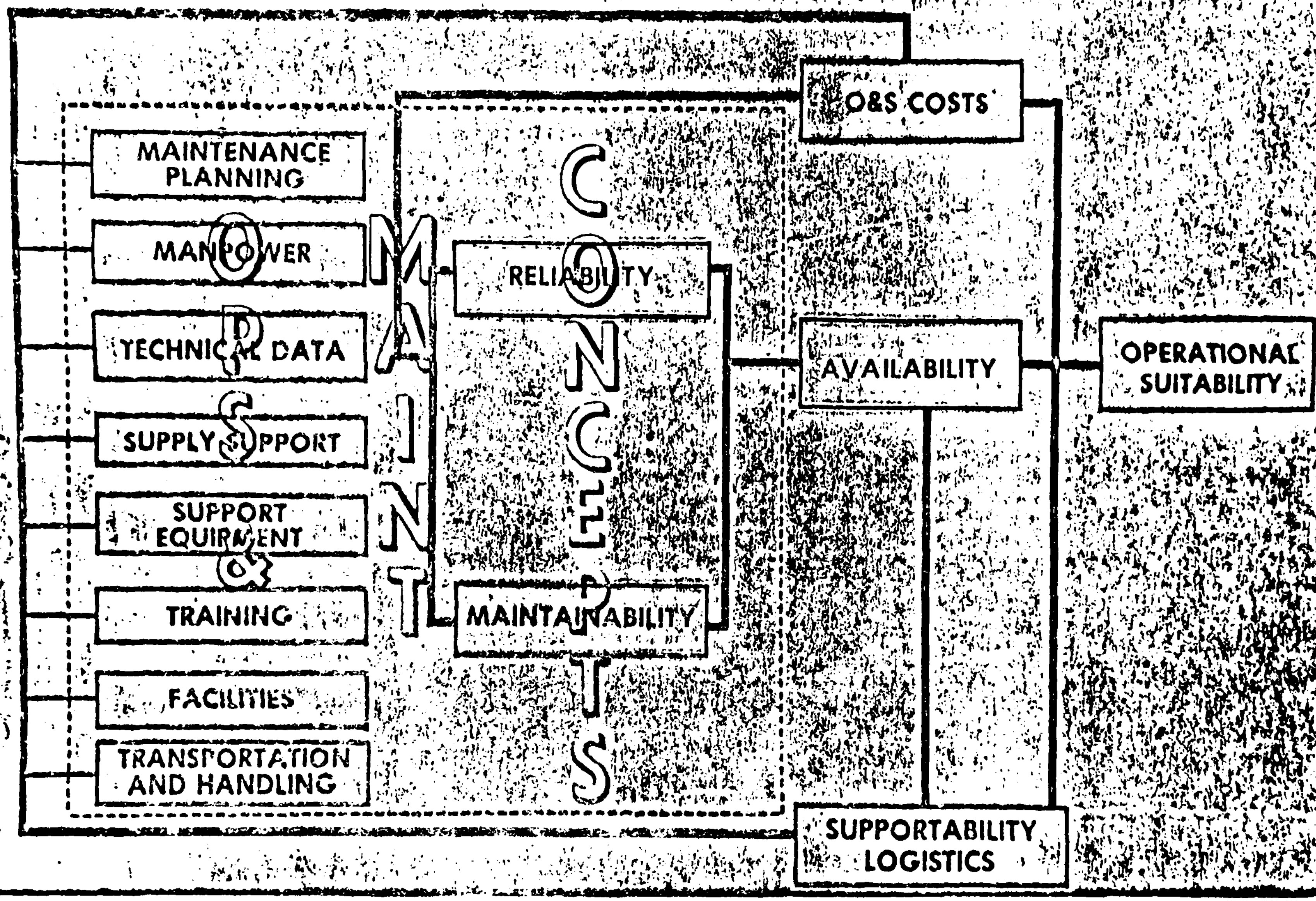
GENERAL OT&E LOGISTICS TEST REQUIREMENTS:

- MEASURE/EVALUATE PRESENT SUITABILITY (AFM 55-43)
- IDENTIFY DEFICIENCIES (AFR 80-14)
- MEASURE/EVALUATE ACTIONS TAKEN TO CORRECT DEFICIENCIES (AFR 80-14)
- PROVIDE DATA FOR DEVELOPMENT OF NECESSARY SYSTEM SUPPORT (AFR 80-14)
- IDENTIFY THE NEED FOR FUTURE TESTING (DODD 5000.3, (AFM 55-43)
- ESTIMATE FUTURE SUITABILITY (AFR 80-14)

T&E PROCESS


OPERATIONAL CONCEPT
MAINTENANCE CONCEPT
OPERATIONAL REQUIREMENTS
SYSTEM DEFINITION
TEST AND ANALYSIS PLANNING
TEST PLANS
OT&E
TEST RESULTS
REPORTING
EARLY DATA
PRELIMINARY ANALYSIS
TEST DATA
SYSTEM ANALYSIS
ANALYSIS RESULTS
CRITICAL ISSUES
MODELING

SUITABILITY ELEMENT INTERACTION



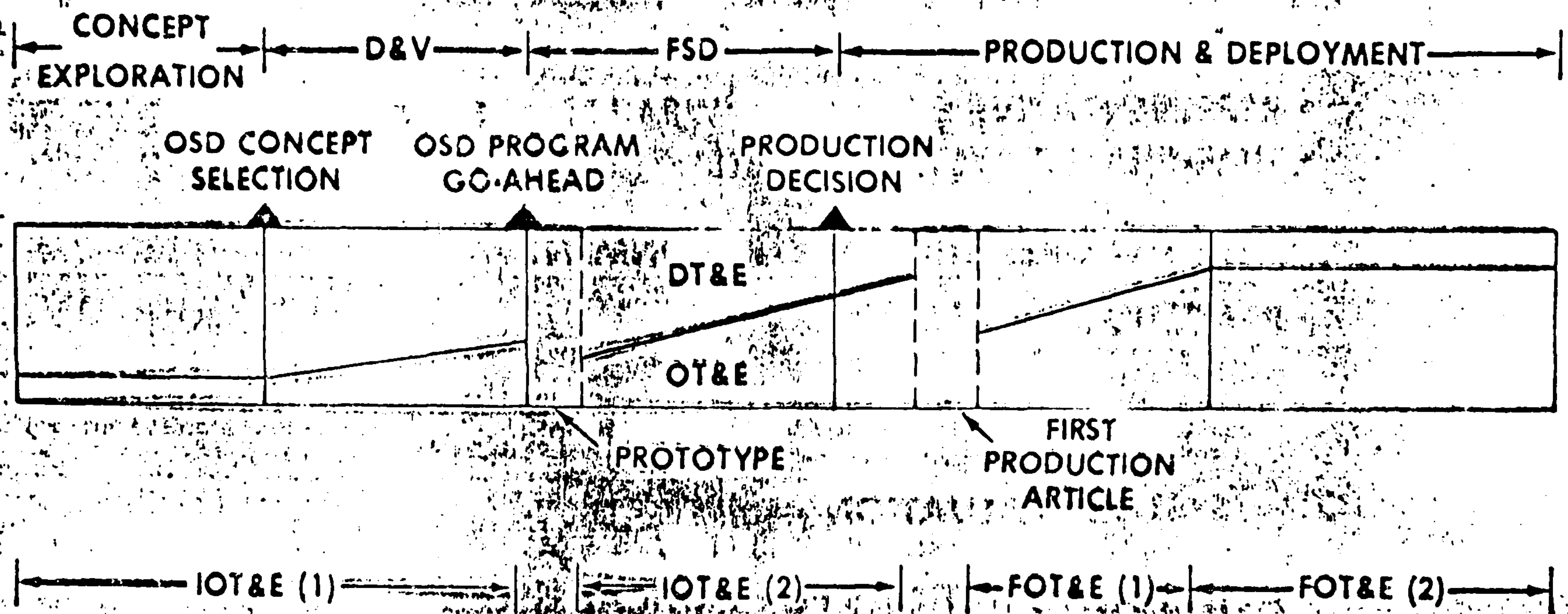
OPERATIONAL SUITABILITY DEFINITION

- THE DEGREE TO WHICH A SYSTEM CAN BE PLACED IN FIELD USE
- WITH CONSIDERATION BEING GIVEN TO
  - AVAILABILITY
  - TRANSPORTABILITY
  - RELIABILITY
  - MAINTAINABILITY
  - HUMAN FACTORS
  - LOGISTICS SUPPORTABILITY
  - TRAINING REQUIREMENTS
  - COMPATIBILITY
  - INTEROPERABILITY
  - WARTIME USAGE RATES
  - SAFETY
  - MANPOWER SUPPORTABILITY
- SOURCE: DODD 5000.3

WHY USE ANALYSIS

- TEST ENVIRONMENT NOT REAL WORLD
  - REPRESENTATIVE SAMPLE OF WEAPON SYSTEM
  - TIME-PHASED SYSTEM EFFECTS
- INSIGHT INTO OPERATIONAL ENVIRONMENT
  - PEACETIME
  - WARTIME
- TOTAL SYSTEM EVALUATION
  - ALTERNATIVE ACTIONS FOR CRITICAL ISSUES
  - ADEQUACY OF PLANNED CONCEPTS AND RESOURCES
  - IMPACTS OF LOGISTICS OPERATIONS

THE TEST AND EVALUATION CYCLE



- DEFINE AND/OR REDUCE DECISION RISK
- DISCOVER DEFICIENCIES AND NEED FOR MODIFICATIONS
- IDENTIFY OPPORTUNITIES FOR IMPROVEMENT

OVERVIEW

- OPERATIONAL TEST AND EVALUATION
- LOGISTICS ASSESSMENT
- MODELING BENEFITS
- SUMMARY

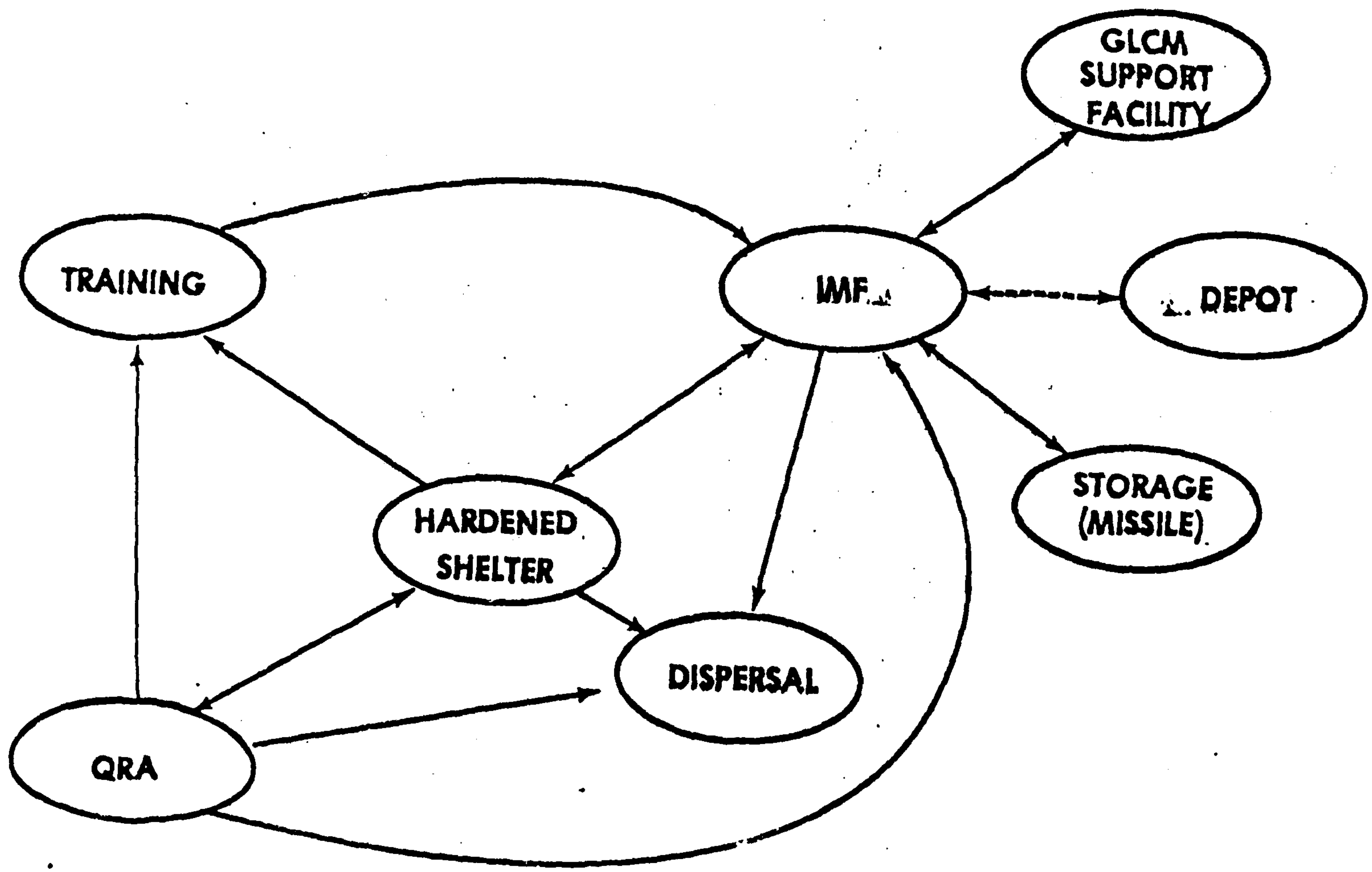
AIR FORCE TEST & EVALUATION CENTER

MODELING GROUND LAUNCHED CRUISE MISSILE AVAILABILITY

MODEL ANALYSIS OBJECTIVES

- ASSESS MATURE GLCM WEAPON SYSTEM AVAILABILITY
- IDENTIFY PROBLEM AREAS IMPACTING AVAILABILITY
- REPORT DEFICIENCIES TO DECISION MAKERS

GLCM SYSTEM FLOW



USE OF Q- GERT MODELING TOOL

"Q-GERT PROVIDES A FRAMEWORK FOR MODELING THE FLOW OF TRANSACTIONS THROUGH PROCESSES. THE FRAMEWORK IS A NETWORK STRUCTURE CONSISTING OF SPECIALIZED NODES AND BRANCHES THAT ARE USED TO MODEL SERVERS, QUEUES FOR SERVERS, ACTIVITIES, AND TRANSACTION FLOW DECISIONS."

SOURCE: A.A.B. PRITSKER (1979), MODELING AND ANALYSIS USING Q-GERT NETWORKS, P. 18.

GLCM AVAILABILITY MODEL ANALYSIS APPROACH

- BASELINE — SPRING 82
  - GD'S R&M AAA REPORT
  - LOGISTICS SUPPORT ANALYSIS RECORD
  - ESTIMATES
- FIRST UPDATE — FALL 82
  - ANALYZE AND INCORPORATE AFT&E TEST DATA
- SECOND UPDATE — SPRING 83
  - PROJECTED MATURE INFORMATION
  - REPORT RESULTS

MODELING IDENTIFIES MAJOR CONCERNS

- IMPACTS ON AVAILABILITY
  - EXTENDED STORAGE — DORMANT RELIABILITY
    - ALCM MODELING RESULTS
    - DORMANT BRIEFING – CAPT SCHWARZ
  - DIAGNOSTICS – BIT CAPABILITY
    - MAINTENANCE CONCEPT'S EXPECTATIONS
    - SOFTWARE DEVELOPMENT
    - IMPACTS ON MANPOWER, SE, TOs
  - INSPECTION CYCLE
    - MAINTENANCE CONCEPT'S EXPECTATIONS
    - FREQUENCY IMPACTS

SUMMARY

- PROBLEM
  - SYSTEM STILL IN DEVELOPMENT
  - MANY TEST LIMITATIONS
  - PROGRAM DOCUMENTS REQUIRE CONTINUOUS UPDATING
- SOLUTION
  - USE MODELING TO PROJECT SYSTEM CAPABILITY
  - IDENTIFY PROBLEMS EARLY
  - UPDATE MODEL AS SYSTEM CHANGES

PREDICTIVE ENGINEERING APPLIED TO USAF AIRCRAFT WHEEL LOGISTICS

ROBERT L. HOWARD
PREDICTIVE ENGINEER
OGDEN ALC

At OO-ALC predictive engineering is being used to measure aircraft wheel service life. Critical data such as (1) the point in time that a wheel begins to enter its wearout phase and (2) its condemnation rate of acceleration are being measured. Frequently, large quantities of wheels are purchased within a short time span. There follows a period in which very few wheels fail. Wheel deterioration tends to be progressive. Therefore, although the wheels are deteriorating, there is little or no evidence of this during the first several years of service. When the wheels reach the wearout phase the wheel failure rate begins to increase. Frequently, the failure rate increases dramatically over a relatively short period of time. This situation can create critical shortages, because procurement lead time for replacement wheels has been as high as 36 months. It is therefore essential that wheel service life be determined at the earliest possible time. Without this determination, aircraft mission capability cannot be guaranteed because stock assets have been depleted and new wheel deliveries are not available for replenishment.

Ideally, the required reliability should be designed into an item using basic physics of failure; for example, assume that a main wheel is to be designed for an aircraft subject to known conditions and environments. The criteria is to design a wheel that is both light in weight and durable. Assume that the durability is specified by the number of years that the wheel is to function. Then applying engineering mechanics, strength of materials, principles of metallurgy, etc. to the specific requirements, it is theoretically possible to design a wheel to meet these specifications. A few wheels with

the given specification would then be produced for testing. These wheels would be tested using a sophisticated computer controlled dynamometer system which would simulate those actual conditions which effect wheel life. A performance evaluation would be made. This procedure would be repeated until a wheel was developed which met the durability requirements. The wheels could then be depended upon to last the specified number of service years. As the end of their life service approached, replacement wheels would be procured and stocked at user bases to prevent grounding of aircraft.

Unfortunately, the ideal situation described above does not exist. While it is easy to measure wheel weight, it is much more difficult to measure durability. As a result, weight often takes precedent over durability. This fact becomes evident when observing that many of the wheel failures result from inadequate material strength in high stress areas. The analytical methods used in the design of the wheel are not sufficiently exacting to guarantee satisfactory results. Also, the qualification testing of the wheels on the dynamometer do not adequately simulate what the wheels actually experience in service. In addition, the real world environment is not very predictable. For example, aircraft may be modified to carry heavier loads or increased armament. Flying hour programs may be dramatically increased. Aircraft may be stationed in areas of high temperature and humidity. Brakes may be modified which results in much higher wheel temperature during braking. Factors such as the above all may contribute to premature wheel failure or condemnations. As a result, reliability and statistical forecasting methods must also be relied upon to measure wheel service life.

The task of the predictive engineer is to first review all available data relative to wheel life characteristics. Historical data pertaining to repairs, condemnations, etc is maintained in the D041 system. The D041 system entitled "Recoverable Consumption Item Requirements System" is used for computation of

recoverable replenishment spares. However, this system maintains only a two year history and uses a 24 month running average to predict future condemnation and repair rates. While this tends to smooth out short term variability, it does not detect short or long term trends. Another source of data is past D041 reports maintained by the equipment specialists (ES). The ES normally maintains from four to six years of repair and condemnation history. The D041 Requirements Computation product provides asset information. This includes quantities of serviceable and unserviceable assets, on order assets, etc. The Item Manager maintains records of past procurement quantities. The responsible engineers maintain records of each condemned item which they have examined. Information such as the date of manufacture, number of previous overhauls and type of failure are recorded. Other pertinent information such as number of wheels in use by the Air Force, FMS, etc is also available. In addition to this objective data, the equipment specialists and engineers have a wealth of subjective information that can greatly assist in the analysis. For example, detailed analysis of the individual failed wheels can provide clues as to what can be expected in the future.

The second step for the predictive engineer is to analyze the available data to determine (1) the length of the wheels life and (2) the condemnation rate of acceleration during the wearout period. Using this information together with other data such as procurement history, it is possible to predict future condemnation rates. These rates are then used to determine procurement dates and quantities. To illustrate the procedure used, the analysis of the F-4 and C-141 main landing gear wheels are provided.

F-4 Main Wheel

Data used in the analysis of the F-4 Main Wheel are shown in Table A. Since a portion of the procured wheels is for support of foreign military sales, adjustments to those quantities were necessary. Of the 8443 wheels procured in FY71-77, 5317 were estimated for Air Force use. This number was arrived at by adding number of wheels in system to those condemned.

Number of Wheels in System	3849
Number Condemned FY77-81	1218
Number Estimated Condemned FY72-76	250
Total	5317

The estimated value for the number condemned in FY72-76 was computed by beginning with the average condemned in FY77-78 rounded to the nearest five. This number (145) is then adjusted by the quantities procured in FY71-72 and FY73-74 and by the inception dates.

$$(145)\ (2013/8443) = 35 \qquad 35 \times 4 = 140$$
$$(145)\ (3214/8443) = 55 \qquad 55 \times 2 = \underline{110}$$
$$250$$

The condemnations history and forecast is shown in Table B. The numbers in column A are used as row numbers. The total condemned, rows 5-9, column F, (5-9, F), are taken from Table A, D041 Factor Printout Data, column E. The m(t) value, column G, represents the number of wheels remaining in the system at the end of the specified year for those items procured in FY71-72. The z(t) value, column H, represents the fraction of those items in the system at the beginning of the year that were condemned during the year. For example:

Value in (9, H) 374/830 = 0.451

The large increase in condemnations (8, F) is attributed to those wheels procured in FY71-72. The wheels procured in FY73-74 and FY75-77 follow a similar pattern. The pattern is seven years of constant failure rate followed by an accelerated rate. The z(t) value for (10, H) is found by cubic polynomial regression using the points (0, 0), (7, 0.041), (8, 0.181), (9, .451). This

TABLE A

DATA USED IN ANALYSIS OF F-4 MAIN WHEEL

1. WHEEL PROCUREMENT HISTORY

A	B	C	D
TIME PERIOD	QUANTITY PROCURED	QUANTITY PROCURED (ADJ TO AF)	INCEPTION DATE FY
FY71-72	2013	1268	72
FY73-74	3214	2024	74
FY75-77	3216	2025	76
	8443	5317	

2. D041 FACTOR PRINTOUT DATA

A	B	C	D	E	F
FY	DEP REP	BASE COND	DEPOT COND	TOTAL C + D	DEPOT COND % D/(B+D)
77	558	81	60	141	10
78	1442	93	53	146	4
79	982	111	42	153	4
80	692	136	158	294	19
81	607	137	347	484	36
	4281	558	660	1218	

3. NUMBER OF WHEELS IN SYSTEM

INSTALLED 1694 X 2QPA =	3388
SPARES	461
TOTAL	3849

CONDEMNATIONS - HISTORY AND FORECAST
(ITEMS PROCURED FY71-77)

A	B	C	D	E	F	G[1]	H	I[1]	J[1]
		NUMBER CONDEMNED YR IN WHICH PROCURED							
YR	FY	FY71-72	FY73-74	FY75-77	TOTAL COND.	FY71-72 m(t)	FY71-72 z(t)	FY73-74 m(t)	FY75-77 m(t)
0	72					1268			
1	73	35			35	1233			
2	74	35			35	1198			
3	75	35	55		90	1163			
4	76	35	55		90	1128			
5	77	35	55	51	141	1093			
6	78	36	55	55	146	1057			
7	79	43	55	55	153	1014	.041		
8	80	184	55	55	294	830	.181		
9	81	374	55	55	484	456	.451	1639	
10	82	403	297	55	755	53	.883 est.	1342	
11	83	53	605	55	713		1.000 est.	737	1644
12	84		650	298	948			87	1346
13	85		87	607	694				739
14	86			653	653				86
15	87			86	86				
TOTALS		1268	2024	2025	5317				

[1] END OF YR QUANTITIES

m(t) represents number of wheels remaining in the system at the end of the specified year

z(t) represents the fraction of those items in the system at the beginning of the year that were condemned during the year

value is 0.833 and is used to determine the estimated number condemned in FY82.

```
(10, H) X (9, G) = (10, C)
0.883 X 456      = 403
```

This same procedure is followed for FY73-74 and FY75-77 data except that the column H data is shifted downward. For example, think of the values in column H shifted down two places so that 0.833 is positioned at (12, H). Then the estimated number of FY73-74 wheels condemned in FY84 is

```
(12, H) X (11, I) = (12, D)
0.883 X 737       = 650
```

By the end of FY87 the wheels procured between FY71-77 should be out of the system.

The depot overhaul condemnation forecast is made in Table C. The number condemned, column B, is taken from Table B, (10-15, F). In column C the quantities condemned for those wheels procured in FY82-84 is computed using the criteria developed earlier.

$$(145/5317) \times 3388 = 92$$

In column D the number of base condemnations is estimated. This is based on the average for FY80-81 taken from the D041 factor printout. Column E represents total condemned at the depot. In column F the number repaired at the depot is estimated. This is based on the average for FY80-81 taken from the D041 factor printout. In column G, the depot condemnation percentages are computed for the forecasted periods shown in column H. These percentages are then input to the D041 system. This system uses these condemnation percentages to compute procurement requirements.

TABLE C

DEPOT OVERHAUL CONDEMNATION FORECAST

Y	B NUMBER COND	C COND (PROCURE FY82-84)	D BASE COND.	E TOTAL COND. DEPOT (B+C-D)	F DEP REPAIR	G DEPOT COND % E/(E+F)	H FORECAST PERIOD
2	755	0	135	620	650	49	Current
3	713	0	135	578	650	47	1^{st}
4	948	92	135	905	650	58	2^{nd}
5	694	92	135	651	650	50	3^{rd}
6	653	92	135	610	650	48	
7	86	92	135	43	650	6	

C-141 Main Wheel

Data used in the analysis of the C-141 Main Wheel are shown in Table D. This includes the wheel procurement history and projection, the D041 Factor Printout Data, and the number of wheels presently in the system. For computational purposes an inception date was established for each procurement period.

Table E contains the condemnation history and forecast for wheels procured in FY70-74. The quantity procured in FY70-74, 3581, is positioned at (0, C). The number of wheels procured in FY70-74 and still remaining in the system is then estimated. This is done by subtracting the total number of wheels procured in FY75-78 from the total number of wheels still in the system. This number (3114 - 989 = 2125) is posiitoned at (9, C). Although some of the wheels procured in FY75-78 have been condemned, this is considered offset by those older than FY70 still in the system.

The factor printout data for number condemned for the years FY78-81 were positioned at (6-9, D). Next, (6-8, C) are completed by using (6-9, D) data and proceeding up the table, adding number condemned during the year to the end of year totals.

R(t), the fraction of the original quantity remaining at the end of a given year, is computed and positioned at (6-9, F). For example, (6, F)

$$(6, C)/(0, C) = 2985/3581 = 0.834$$

The data points (6-9, A & F) were found to follow a Weibull Distribution. This was discovered by taking the natural logarithms twice of the Weibull distribution,

$$R(t) = \exp\left(-(t/\theta)^k\right), \text{ to achieve,}$$

$$\ln(-\ln R(t)) = -K \ln \theta + K \ln t$$

This is a linear model of the form $y = a + bx$ with $a = -K \ln \theta$ and $b = K$. The

TABLE D

DATA USED IN ANALYSIS OF C-141 MAIN WHEEL

1. Wheel Procurement History and Projection

TIME PERIOD	QTY PROCURED	INCEPTION DATE (FY)
FY70-74	3581	72
FY75-78	989	77
FY82-84	3791	83

2. D041 Factor Printout Data

A FY	B DEP REP	C BASE COND	D DEP COND	E TOTAL C + D
78	706	11	81	92
79	1235	32	195	227
80	1321	67	318	385
81	993	43	205	248
TOTAL	4255	153	799	952

3. Number of Wheels in System

INSTALLED	274 X 8 QPA =	2192
SPARES		922
TOTAL		3114

TABLE E

CONDEMNATIONS - HISTORY AND FORECAST

(Items Procured - FY70-74)

A	B	C	D	E	F	G
YR NO	FY	TOTAL QTY (END OF YR)	QTY COND (DURING YR)	QTY COND (CATEGORY)	R (t) (ACTUAL)	R (t) (PREDICTED)
0	72	3581				
6	78	2985	92	Actual	0.834	0.843
7	79	2758	227	Actual	0.770	0.770
8	80	2373	385	Actual	0.663	0.685
9	81	2125	248	Actual	0.593	0.593
10	82	1781	344	Predicted		0.497
11	83	1443	338	Predicted		0.403
12	84	1128	315	Predicted		0.315
13	85	848	280	Predicted		0.237
14	86	612	236	Predicted		0.171
15	87	423	189	Predicted		0.118
16	88	279	144	Predicted		0.078
17	89	175	104	Predicted		0.049
18	90	105	70	Predicted		0.029
19	91	59	46	Predicted		0.017
20	92	0	59	Predicted		0.009

data points (6, 0.834), (7, 0.770), (8, 0.663), (9, 0.593) are transformed to,

ln t	ln (-ln R(t))
1.79176	-1.70638
1.94591	-1.34184
2.07944	-0.88921
2.19722	-0.64901

and computer plotted in Figure 1. Since these points follow a linear function, it can be assumed that the Weibull distribution adequately describes these data points. The coefficient of correlation equals 0.99 ($R^2 = 0.99$) indicating an excellent fit. The parameters of the Weibull distribution were then computed to provide a slightly larger slope to the line and thereby provide a small margin of safety. Only the points (7, 0.770) and (9, 0.593) were used in this computation. The values of the parameters are $K = 2.75687$ and $\theta = 11.38890$. Using these parameters, R(t) for each year is computed and placed in column G of Table E. The R(t) values for t = 1-20 were used to compute quantities condemned for those wheels procured in the FY75-78 and FY82-84 time periods.

The responsible engineer estimates that 40% of the wheels procured in FY70-74 have heat damage. It was therefore necessary to make adjustments for this. It is estimated that there are 2125 wheels from this time period still in the system (See Table E, (9, C)). Thus, 0.40 X 2125 = 850 wheels which were expected to have been condemned in FY86-92 are shifted up to FY82-83 (Table F). As a result, all wheels procured in FY70-74 should be out of the system by the end of FY85. Condemned quantities may increase by about 100 per year in FY86-88 as a result of heat damage to wheels procured in FY75-78. No heat damage was forecasted for those wheels to be procured in FY82-84 because engineering modifications to the wheel should reduce this damage.

The projected condemnation quantities are used to project condemnation rates. These rates are then used in the D041 system to forecast procurement requirements.

C-141 MAIN WHEEL

CONDEMNATION DATA FIT TO THE WEIBULL DISTRIBUTION

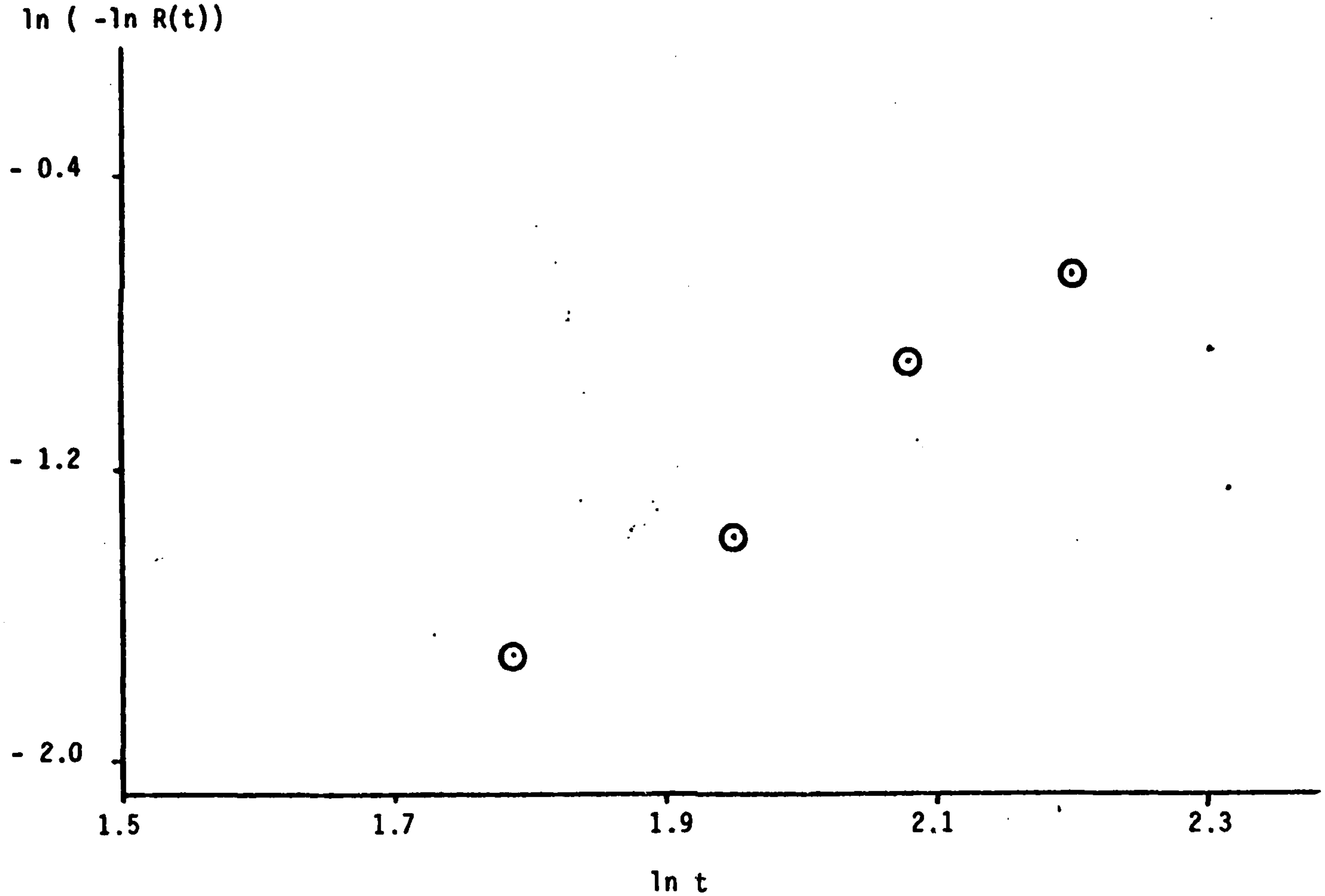


TABLE F

CONDEMNATIONS - FORECAST SUMMARY

A	B	C	D	E	F	G
FY (END OF YR)	COND ITEMS PROCURED FY70-74	HEAT DAMAGE	COND ITEMS PROCURED FY75-78	HEAT DAMAGE	COND ITEMS PROCURED FY82-84	COND TOTALS B + C + D + E
82	344	425	70			839
83	338	425	85			848
84	315		72		5	392
85	280		84		27	391
86	236		92	100	63	255
87	189		94	100	111	305
88	144		93	112	166	371
89	104		87		223	310
90	70		78		276	276
91	46		65		321	321
92	59		52		350	350
93	0		40		363	363
94			29		357	357
95			19		334	334
96			13		296	296
97			16		250	250
98			0		200	200
99					152	152

Predictive Engineering Applied to Other Areas

Predictive engineering can be applied to any recoverable item in which a consumption history has been maintained. Predictive engineering may also be used as a basis for cost evaluations of proposed systems. This is especially true when projected costs of existing systems based on passed performance and predicted future performance can be determined. It is then necessary for the proposer of the new system to provide substantive evidence for monetary savings. Present value analysis which considers both yearly and initial costs as well as money worth and inflation rates is then applied to determine which method is most cost effective. Of course, cost is only one factor in determining whether or not a proposed system should be accepted. Other factors such as increased combat effectiveness, safety, reliability, availability of spare parts, etc. all must be evaluated before a final decision can be made.

There are, no doubt, other uses for the methods developed here. The important point to remember is that these methods provide management with a more objective approach to decision making.

USING MICROCOMPUTERS TO ASSESS BASE-LEVEL MUNITIONS CAPABILITY

CAPT MARK GREENLY

AFLMC LGM

This briefing describes a base-level munitions production simulation. Although created for the Munitions Officer Course at Lowry Tech Training Center, it could be adapted to assess base-level munitions capability. The briefing begins with some remarks about microcomputers, the munitions support process, and germane capability assessment questions. After describing the simulation and proposing some modifications, the briefing closes by discussing some issues the Air Force should address before management tools like this can be widely used.

MICROCOMPUTER CHARACTERISTICS

HARDWARE . . .

CAPABILITIES - Up to 64K bytes of Random Access Memory (although some machines are marketed with up to 512K), disc storage, printer, modem, CRT if required.

COST - Up to $5000 for this system.

USER . . .

The manager of munitions operations at workcenter, branch, or squadron level.

ACCESS - Freedom to get at, and get on, the machine at a time convenient to the manager.

CONTROL - of what programs are used and written, rather than relying on "turnkey" programs.

UNDERSTANDING - Enough of a grasp of the machine and its programming language to create customized programs.

MUNITIONS SUPPORT PROCESS

RECEIPT

STORAGE

BREAKOUT

ASSEMBLY

PRELOAD

FLIGHTLINE DELIVERY

AIRCRAFT LOADING

These are the major stages in the munitions support process from the time munitions arrive at the base until they are loaded on aircraft for sortie generation. The exact sequence of steps depends on the munitions type. All these steps except the last one are done by the munitions storage area personnel.

CAPABILITY ASSESSMENT ISSUES

WHAT MANAGEMENT POLICIES SHOULD I USE ?

CAN I SUPPORT A NEED FOR MORE RESOURCES ?

These are examples of the kind of capability assessment questions facing the branch or workcenter manager. They deal with the short-term, often day-to-day, management of resources. An example of a management policy to be explored at this level would be the assignment of personnel to different workshifts and the time various shifts came on duty. The need for more resources would be one which could be supplied locally, e.g., general purpose vehicles from elsewhere on base, or augmentee personnel for tasks requiring a minimum of training.

MSA SIMULATION EXERCISE

MUNITIONS OFFICER COURSE AT LOWRY TTC

- Gives officers practice in making decisions related to management of tasks and resources in munitions storage area operation.

WRITTEN IN BASIC .. 23K BYTES

- Automates the computational, and some recordkeeping, functions of the exercise. Players must still, by design, track many resources by hand. This program size will model a two-day scenario at the level of detail used at Lowry.

3 TYPES OF MUNITIONS

- MK 82 General Purpose Bombs, AGM-65 Maverick Missile, MK 20 Rockeye Anti-Tank Munition.

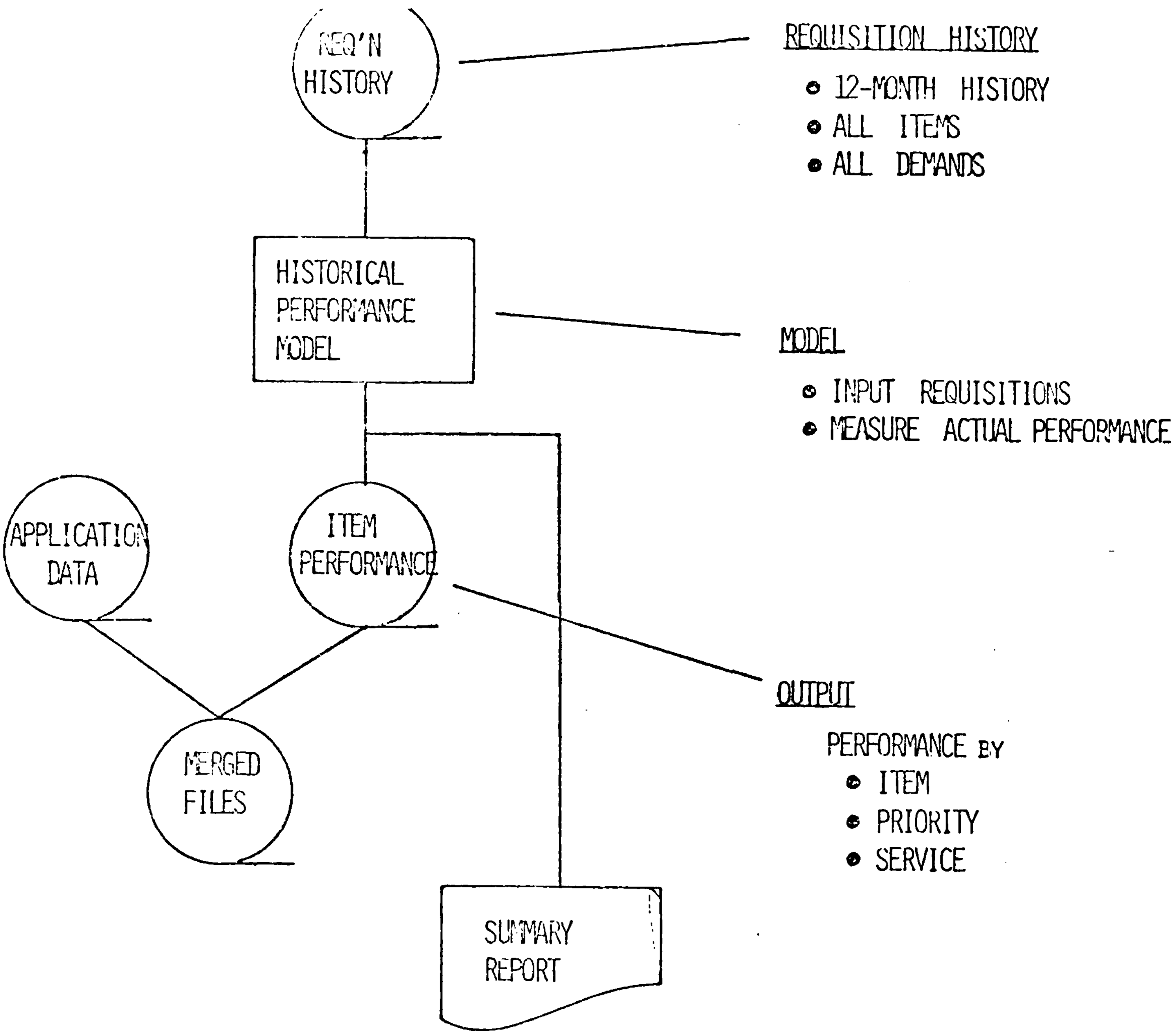
2 TYPES OF TRAILERS

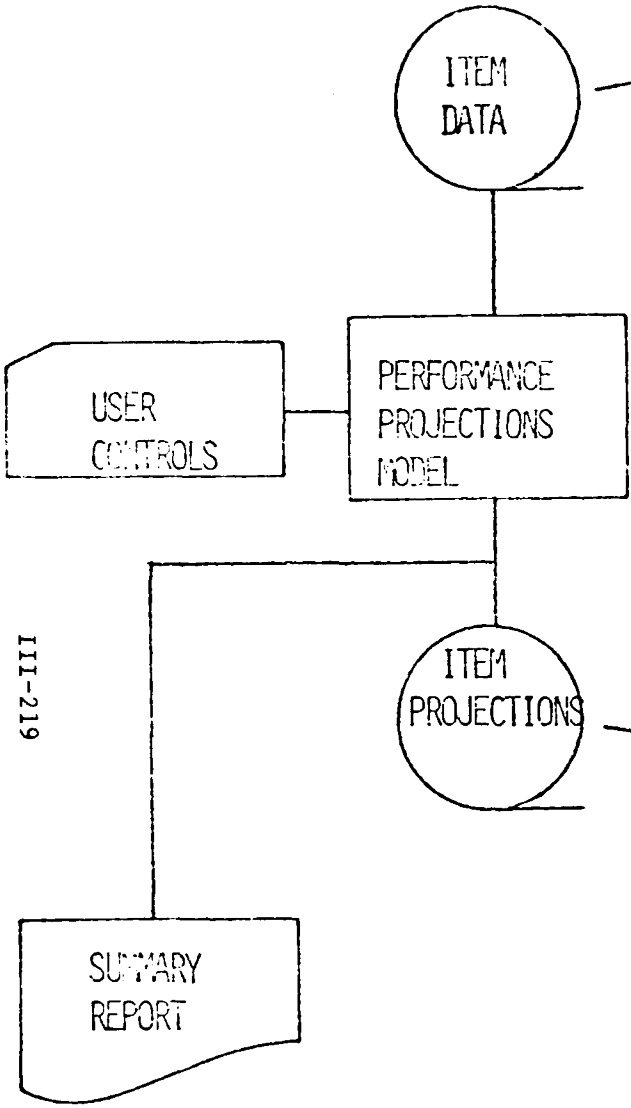
- MHU-12/M and MHU-85/M trailers are tracked by the program. Other resources (personnel, vehicles, other equipment) are tracked by the players.

OPERATOR MAKES ALL THE DECISIONS

- Because the program asks players for an input at every decision point, the simulation of only two days requires 4 to 6 hours. This is too slow for use in field units where a manager may wish to make many different runs to explore various managment options.

A sample output from the program is at Attachment 1.


REQ'N HISTORY
HISTORICAL PERFORMANCE MODEL
APPLICATION DATA
ITEM PERFORMANCE
MERGED FILES
SUMMARY REPORT
REQUISITION HISTORY
• 12-MONTH HISTORY
• ALL ITEMS
• ALL DEMANDS
MODEL
• INPUT REQUISITIONS
• MEASURE ACTUAL PERFORMANCE
OUTPUT
PERFORMANCE BY
• ITEM
• PRIORITY
• SERVICE



ITEM DATA

- ITEM LEVELS
- DEMAND PATTERNS
- WEAPON APPLICATIONS

MODEL

- INPUT: ITEM DATA
  USER CONTROLS
- COMPUTE: EXPECTED SUPPLY PERFORMANCE

OUTPUT

- ITEM DATA
- PERFORMANCE BY ITEM
- WEAPON APPLICATIONS

DLA

Materiel Readiness

Support (MARS) Model

2. Future Support Analyses. The MARS model will be able to produce statistics that predict DLA's future support to a weapon system or organizational unit or combination of both. After identifying what items are used by the weapon system and/or organizational unit, the model will use inventory control theory to compute performance for those items in the coming year. The computation will involve current assets, expected requirements, and historical demand variance as well as relationships between previously predicted support statistics and actual support statistics. Those relationships will help isolate support to the particular weapon system and/or organizational unit for multi-application items.

3. Planning and Budgeting Analyses. The MARS model will be able to predict future support to a weapon system and/or organizational unit under a variety of budget alternatives. As outlined above, the model will first identify appropriate items and then will compute from available data their performance for a given budget alternative. Model outputs will allow for plots of support versus different levels of budget dollars as well as plots of support versus differing dollar allocations. These plots or statistics should aid DLA in supporting its budget requests.

4. Materiel Readiness Management. As a tool for predicting support to any weapon system or organizational unit, the MARS model will allow DLA management to work closer with Service project managers in coordinating support to special/critical projects and/or projects directly tied to military readiness. If service managers provide DLA with specific support requirements, DLA will be able to determine how best to meet those requirements either by increased allocation or reallocation of budget dollars. This should serve to increase the partnership between the Services and DLA.

5. Mobilization Studies. Although not in the original development of the MARS model, a future use of the model will be studies of DLA's support to mobilization scenarios. The model will provide for mobilization factors that would reflect increased demand for items in a mobilization scenario. Statistics from the model will show what support would be under the increased demand.

Summary. The MARS model will measure both the quality and quantity of support that DLA is giving to a service entity or to a weapon system or to some combination of the two.

PRESENTED BY CAPT WILLIAM R. FRAZIER, DLA/LOO.

Overview of MARS Model and its Capabilities

Purpose. The purpose of the DLA Materiel Readiness Support (MARS) Model will be to produce performance and cost measures that show how well DLA is supporting military readiness.

Scope. The MARS Model will include all hardware and medical items managed by DLA, particularly those in the DLA Weapon System Support Program (WSSP). The WSSP covers 116 systems and over 208,000 items. The model will exclude fuel, clothing and textiles, and subsistence.

MARS performance and cost measures will be item-oriented. If an item is identified to a weapon system or service entity, all activity on that item will be included in the MARS measures, unless unrelated activity can be isolated and omitted. Only when an item is identified to a weapon system or service entity, will its activity be included in the MARS measures.

Data Requirements. The data base to support the model will be drawn from several files in DLA's Standard Automated Materiel Management System (SAMMS). Data from the SAMMS Supply Control File will indicate which items are used on which weapon systems and will also provide information on item requirement levels. Data on item demand and backorders will come from the Transaction and Requisition History Files, while data on stock levels will be drawn from the National Inventory Record file. The MARS data base will be initially maintained at DLA Headquarters and updated as required. The data base will be structured so that if the DLA Supply Centers have a need to run the model they can. All data will be able to be grouped by weapon system or service entity. This will be accomplished by using the weapon system designator for a weapon system code and the appropriate DoDAAC or group of DoDAAC's for a service entity. If required, the ability to group items on other codes, such as the VIP/critical item indicator, will be included.

Model Output. MARS will produce reports on four performance measures and five cost measures. The performance measures would be supply availability, response time, average lines on backorder, and average time on backorder. The cost measures would be stock fund investment, commitments/obligations, safety level value, annual variable cost, and average value of backorders. Statistics on all of these measures will include totals, averages, distributions, and identifications of key items. Values for statistics will be predictive as well as historical.

Capabilities. MARS model will have the following uses within DLA:

1. Historical Support Analyses. The MARS model will be able to produce statistics that show DLA's historical support to a weapon system or organizational unit or combination of both. Using demand history on items used by the weapon system and/or organizational unit, the model will identify the supply performance for those items. Although demands for weapon system items may come from non-weapon system applications, the model will use all available indicators to try to isolate weapon system applications.

DAY 1 TIME 2 37

FUNCTIONS: 1 = MUNITIONS STATUS. 2 = JOB START.3 = CLOCK ADVANCE
WHICH ONE DO YOU SELECT 2

DAY 1 TIME 2 37

ENTER START TIME (DAY,HOUR, MINUTE SEPARATED BY COMMAS) 1,2,45

DAY 1 TIME 2 45

TO CANCEL A JOB START AND SELECT ANOTHER FUNCTION,
INPUT 999 TO ANY OF THE NEXT FOUR QUESTIONS.

THIS IS JOB NUMBER 2

ENTER TASK TYPE (CBO,ASY, OR DEL) ASY
ENTER MUNITIONS TYPE (MK82,MK20,AGM65) MK82
ENTER NUMBER OF MHU-85/M TRAILERS TO BE USED 3
ENTER NUMBER OF MHU-12/M TRAILERS TO BE USED 1
NUMBER OF TRAILERS YOU ASSIGNED EQUATES TO MUNITIONS
TOTAL OF 42
IS THIS WHAT YOU INTENDED? (Y OR N) Y
JOB START NOTED. HIT RETURN r

DAY 1 TIME 2 45

FUNCTIONS: 1 = MUNITIONS STATUS. 2 = JOB START.3 = CLOCK ADVANCE
WHICH ONE DO YOU SELECT 1

DAY 1 TIME 2 45

KEY: MUNITIONS TOTAL / # MHU 12 # MHU-85

	IN STORAGE	BROKEN OUT	ASSEMBLED	DELIVERED
MK 82	728	30 / 1 2	48 / 4 2	0
MK 20	800	XXXXXXXX	56 / 4 4	0
AGM65	800	0 / 0 0	36 / 6 6	0

	CBO IN PROGRESS	ASY IN PROGRESS	DEL IN PROGRESS
MK 82	0 / 0 0	42 / 1 3	0 / 0 0
MK 20	0 / 0 0	XXXXXXXX	0 / 0 0
AGM65	0 / 0 0	0 / 0 0	0 / 0 0

HIT RETURN r

DAY 1 TIME 2 45

FUNCTIONS. 1 = MUNITIONS STATUS. 2 = JOB START.3 = CLOCK ADVANCE
WHICH ONE DO YOU SELECT

```
                                              DAY 1 TIME 1  5

FUNCTIONS: 1 = MUNITIONS STATUS. 2 = JOB START.3 = CLOCK ADVANCE
WHICH ONE DO YOU SELECT 3
```

```
                                              DAY 1 TIME 1  5

YOU CAN ADVANCE THE CLOCK IN TWO WAYS
(1 = TO THE NEXT EVENT; 2 = SOME AMOUNT YOU SPECIFY)
WHAT IS YOUR CHOICE 1
```

```
                                              DAY 1 TIME 2  18

THE CLOCK HAS ADVANCED TO THE TIME SHOWN.
YOU MUST DEAL WITH THIS EVENT BEFORE PROCEEDING.

PROBLEM NUMBER . 1             OCCURS AT THIS TIME.
HIT RETURN
```

```
                                              DAY 1 TIME 2  18

FUNCTIONS: 1 = MUNITIONS STATUS. 2 = JOB START.3 = CLOCK ADVANCE
WHICH ONE DO YOU SELECT 3
```

```
                                              DAY 1 TIME 2  18

YOU CAN ADVANCE THE CLOCK IN TWO WAYS
(1 = TO THE NEXT EVENT; 2 = SOME AMOUNT YOU SPECIFY)
WHAT IS YOUR CHOICE 1
```

```
                                              DAY 1 TIME 2  37

THE CLOCK HAS ADVANCED TO THE TIME SHOWN.
YOU MUST DEAL WITH THIS EVENT BEFORE PROCEEDING.

JOB NUMBER        1            COMPLETED AT THIS TIME
HIT RETURN
```

```
                                              DAY 1 TIME 2  37

KEY:  MUNITIONS TOTAL / # MHU 12  # MHU-85

                 IN           BROKEN       ASSEMBLED      DELIVERED
               STORAGE         OUT

MK 82           728          72 / 2  5     48 / 4  2         0
MK 20           800          XXXXXXXX      56 / 4  4         0
AGM65           800          0 / 0  0      36 / 6  6         0

                  CBO IN         ASY IN        DEL IN
                  PROGRESS       PROGRESS      PROGRESS

MK 82             0 / 0  0       0 / 0  0      0 / 0  0
MK 20             0 / 0  0       XXXXXXXX      0 / 0  0
AGM65             0 / 0  0       0 / 0  0      0 / 0  0

HIT RETURN
```

DAY 1 TIME 0 45

YOU CAN ADVANCE THE CLOCK IN TWO WAYS
(1 = TO THE NEXT EVENT; 2 = SOME AMOUNT YOU SPECIFY)
WHAT IS YOUR CHOICE 1

DAY 1 TIME 1 3

THE CLOCK HAS ADVANCED TO THE TIME SHOWN.
YOU MUST DEAL WITH THIS EVENT BEFORE PROCEEDING.

FRAG NUMBER 1 RECEIVED AT THIS TIME
HIT RETURN ~

DAY 1 TIME 1 3

FUNCTIONS: 1 = MUNITIONS STATUS. 2 = JOB START.3 = CLOCK ADVANCE
WHICH ONE DO YOU SELECT 2

DAY 1 TIME 1 3

ENTER START TIME (DAY,HOUR, MINUTE SEPARATED BY COMMAS) 1,1,5

DAY 1 TIME 1 5

TO CANCEL A JOB START AND SELECT ANOTHER FUNCTION,
INPUT 999 TO ANY OF THE NEXT FOUR QUESTIONS.

THIS IS JOB NUMBER 1

ENTER TASK TYPE (CBO,ASY, OR DEL) CBO
ENTER MUNITIONS TYPE (MK82,MK20,AGM65) MK82
ENTER NUMBER OF MHU-85/M TRAILERS TO BE USED 5
ENTER NUMBER OF MHU-12/M TRAILERS TO BE USED 2
NUMBER OF TRAILERS YOU ASSIGNED EQUATES TO MUNITIONS
TOTAL OF 72
IS THIS WHAT YOU INTENDED? (Y OR N) Y
JOB START NOTED. HIT RETURN ~

DAY 1 TIME 1 5

FUNCTIONS: 1 = MUNITIONS STATUS. 2 = JOB START.3 = CLOCK ADVANCE
WHICH ONE DO YOU SELECT 1

DAY 1 TIME 1 5

KEY: MUNITIONS TOTAL / # MHU 12 # MHU-85

	IN STORAGE	BROKEN OUT	ASSEMBLED	DELIVERED
MK 82	728	0 / 0 0	48 / 4 2	0
MK 20	800	XXXXXXXX	56 / 4 4	0
AGM65	800	0 / 0 0	36 / 6 6	0

	CBO IN PROGRESS	ASY IN PROGRESS	DEL IN PROGRESS
MK 82	72 / 2 5	0 / 0 0	0 / 0 0
MK 20	0 / 0 0	XXXXXXXX	0 / 0 0
AGM65	0 / 0 0	0 / 0 0	0 / 0 0

HIT RETURN ~

```
WELCOME TO THE MUNITIONS ASSEMBLY AND DELIVERY MANAGEMENT
EXERCISE.  FOR CONVENIENCE' SAKE, ABBREVIATE IT AS

          ****************************

             M A D -- M A N -- X

          ****************************

YOU HAVE FILE SPACE FOR 61 JOBS
YOU WILL BE ADVISED WHEN YOU APPROACH THIS LIMIT.
HIT 'RETURN'
```

```
                                   DAY 1 TIME 0  0

FUNCTIONS: 1 = MUNITIONS STATUS. 2 = JOB START.3 = CLOCK ADVANCE
WHICH ONE DO YOU SELECT 1
```

```
                                   DAY 1 TIME 0  0

KEY:  MUNITIONS TOTAL / # MHU 12  # MHU-85

              IN          BROKEN       ASSEMBLED     DELIVERED
            STORAGE        OUT
MK 82         800        0 / 0  0      48 / 4  2        0
MK 20         800        XXXXXXXX      56 / 4  4        0
AGM65         800        0 / 0  0      36 / 6  6        0

              CBO IN          ASY IN          DEL IN
              PROGRESS        PROGRESS        PROGRESS
MK 82         0 / 0  0        0 / 0  0        0 / 0  0
MK 20         0 / 0  0        XXXXXXXX        0 / 0  0
AGM65         0 / 0  0        0 / 0  0        0 / 0  0

HIT RETURN
```

```
                                   DAY 1 TIME 0  0

FUNCTIONS: 1 = MUNITIONS STATUS. 2 = JOB START.3 = CLOCK ADVANCE
WHICH ONE DO YOU SELECT 3
```

```
                                   DAY 1 TIME 0  0

YOU CAN ADVANCE THE CLOCK IN TWO WAYS
(1 = TO THE NEXT EVENT; 2 = SOME AMOUNT YOU SPECIFY)
WHAT IS YOUR CHOICE 2
HOW MANY MINUTES DO YOU  WANT THE CLOCK ADVANCED 45
```

```
                                   DAY 1 TIME 0  45

FUNCTIONS: 1 = MUNITIONS STATUS. 2 = JOB START.3 = CLOCK ADVANCE
WHICH ONE DO YOU SELECT 3
```

a. Manage the calendar of events, and update it as jobs are started.

b. Present each event to the players at the proper time.

c. Compute all task times.

d. Present the clock time and update it at the players request.

e. Present and update charts on munitions status.

A sample output is shown on the following pages. Player responses have been written in. While this is not a complete period of play, it shows each of the major features which the players will see.

This appendix describes the microcomputer software which has been created to support some of the computational and record-keeping functions of the exercise. A listing of the program and its documentation is in Part II of this report. It is available to authorized agencies. Requests for release should be made IAW AFR 300-6, para 11-7, and directed to AFLMC/XR, Gunter AFS, AL 36114.

LENGTH: As written, the program requires 23K to execute. The actual requirement for any particular user is dependent on two things:

a. The program has numerous comments and spacing lines in it to improve programmer readability and understanding. These can be removed without affecting execution.

b. The program is built around an event file in which all events presented to the players are stored. The length of this file can be changed to vary the number of jobs which the players can perform in the course of play. The 23K length allows for a file capable of storing 75 events. Space for each additional 25 events added to this file requires about 1.5K additional.

LANGUAGE: BASIC. The version which will be provided to requesters will be in code written for a WANG 2200 system. Modifying this code to run on another brand of machine would not be a major undertaking, but it will be the responsibility of the requester.

FUNCTIONS: The program will perform these functions for the exercise:

Excerpted From:

MUNITIONS STORAGE AREA
SIMULATION GAME

AFLMC REPORT NO. 8009C2
November 1981

Appendix F

Computer Program Description

These categories represent some potential problems which may need to be faced before any microcomputers and capability assessment programs are widely used at base-level.

ISSUES TO BE FACED

MUNITIONS STANDARDIZATION

- The variety of munitions, equipment, and production techniques used in different commands may impede the Air Force-wide use of programs designed to model any situation in great detail.

HARDWARE

- What organizational level buys the hardware? Who decides what is bought for what users? How is the equipment maintained and repaired when the owning unit may be deploying world-wide?

PROGRAMMING

- Will the Air Force cultivate unit-level programming expertise, or allow it to grow to a "self-taught" basis? Will managers who write their own capability assessment programs be allowed to use them as they see fit, or will only "approved" programs be permitted? How will security be maintained on programs analyzing classified data?

This list is by no means complete. Each potential application will require many decisions to be made. To see how one application is being considered, see TAC ATTACK Magazine, Nov 1981, "The Micros are Coming." Although this is not a munitions application, the information on how the hardware and programming will be handled is germane.

MODIFICATIONS TO MSA SIMEX

- To allow the program to do more for the operator, and to do it faster.

MORE RESOURCES TRACKED BY PROGRAM

- Personnel and equipment besides trailers and munitions.

LARGER EVENT FILES

- To allow modeling of a longer period of time in greater detail.

DECISION MAKING RULES

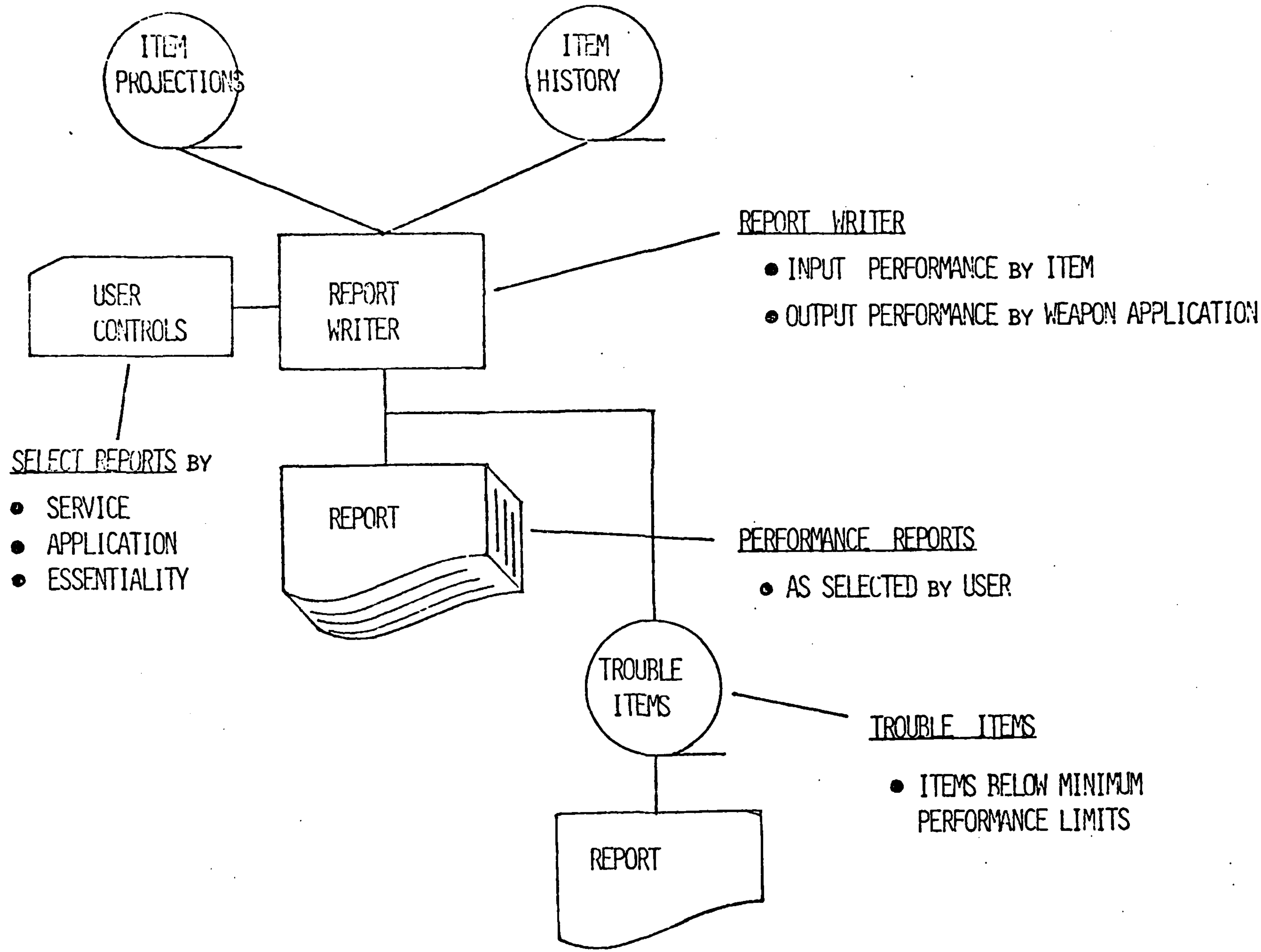
- To speed up execution by relieving the operator of having to make an input at each decision point.

COLLECTION OF STATISTICS

- To show utilization rates of equipment, percent of tasks completed on time, etc.

HARDWIRING OF MAJCOM CHARACTERISTICS

- Types of munitions, production techniques, specialized pieces of equipment, etc.


ITEM PROJECTIONS
ITEM HISTORY
REPORT WRITER
USER CONTROLS
REPORT
TROUBLE ITEMS
REPORT
REPORT WRITER
• INPUT PERFORMANCE BY ITEM
• OUTPUT PERFORMANCE BY WEAPON APPLICATION
SELECT REPORTS BY
• SERVICE
• APPLICATION
• ESSENTIALITY
PERFORMANCE REPORTS
• AS SELECTED BY USER
TROUBLE ITEMS
• ITEMS BELOW MINIMUM PERFORMANCE LIMITS

OTHER FEATURES

- SELECT ITEMS BY:
  - USER (ACTIVITY ADDRESS CODE)
  - ITEM CHARACTERISTICS (VIP, MOB RESERVE, ETC.)
  - DEMAND PRIORITY (E.G., ALL ITEMS WITH HI-PRI DEMANDS)
  - ANY COMBINATION

- REFINE FEATURE
  - COMPARE ACTUAL vs PROJECTED SUPPORT MEASURES
  - ANALYZE DIFFERENCES
  - REFINE PERFORMANCE PROJECTION MODELS

DLA MATERIEL READINESS SUPPORT SYSTEM
PROJECTED SUPPLY PERFORMANCE

WEAPON/APPLICATION 1
XXXXXXXXXXXXXXX

NUMBER OF ITEMS IN W/S	4
NUMBER OF REQUISITIONS	44.
TOTAL ANNUAL DMD VALUE	90.00

AVG LINES ON BACKORDER 19.97

SUPPLY AVAIL %	AVG	HIGH	LOW	NO DMD	100.00	95.00	90.00	80.00	50.00	30.00	< 30.00
OVERALL	52.27	0.65	0.0	0	2	0	0	0	1	1	0
12-MONTH	38.64	2.50	0.0	0	1	0	0	0	1	0	2

AVG TIME ON B/O	AVG	HIGH	LOW	NO DMD	0.0	10.00	25.00	45.00	60.00	90.00	> 90.00
OVERALL	295.48	365.00	0.0	0	2	0	0	0	0	0	2
12-MONTH	40.56	52.14	0.0	0	2	0	0	0	2	0	0

RESPONSE TIME	AVG	HIGH	LOW	NO DMD	0.0	5.00	10.00	20.00	30.00	50.00	> 50.00
OVERALL	141.02	237.25	0.0	0	2	0	0	0	0	0	2
12-MONTH	24.89	36.50	0.0	0	2	0	0	1	0	1	0

DLA MATERIEL READINESS SUPPORT SYSTEM
HISTORICAL SUPPLY PERFORMANCE

WEAPON/APPLICATION 1 XXXXXXXXXXXXXXX

NUMBER OF ITEMS IN W/S 4
NUMBER OF REQUISITIONS 36.

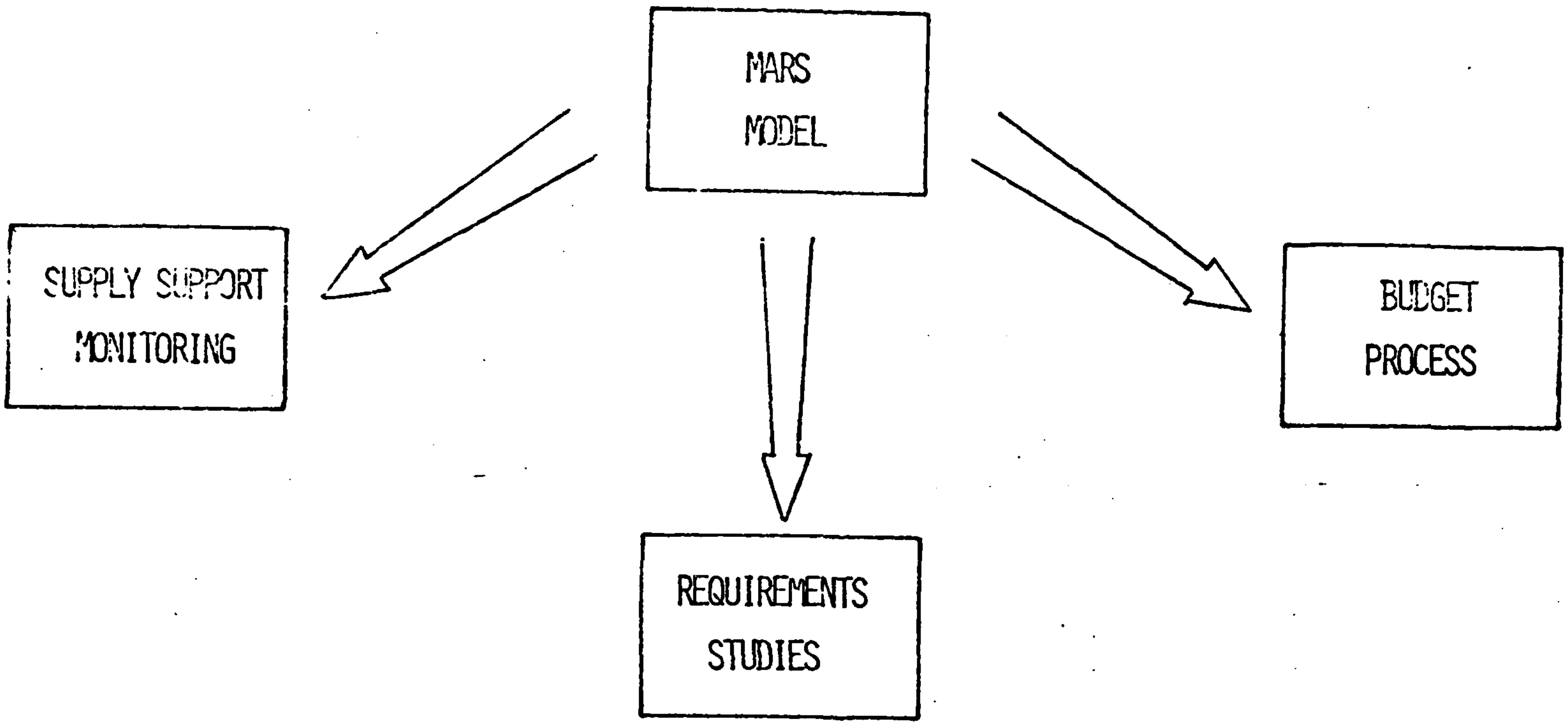
AVG LINES ON BACKORDER 7.68

SUPPLY AVAIL %	AVG	HIGH	LOW	NO DMD	100.00	100.00 TO 95.00	95.00 TO 90.00	90.00 TO 80.00	80.00 TO 50.00	50.00 TO 30.00	< 30.00
I	27.27	0.40	0.0	1	0	0	0	0	0	1	2
II	36.36	0.50	0.25	1	0	0	0	0	1	1	1
III	21.43	1.00	0.0	0	1	0	0	0	0	0	3
TOT	27.78	1.00	0.14	0	1	0	0	0	0	1	2

AVG TIME ON B/O	AVG	HIGH	LOW	NO DMD	0.0	0.0 TO 10.00	10.00 TO 25.00	25.00 TO 45.00	45.00 TO 60.00	60.00 TO 90.00	> 90.00
I	364.62	365.00	364.33	1	0	0	0	0	0	0	3
II	364.43	364.67	364.00	1	0	0	0	0	0	0	3
III	364.18	365.00	0.0	0	1	0	0	0	0	0	3
TOT	363.92	364.53	0.0	0	1	0	0	0	0	0	3

RESPONSE TIME	AVG	HIGH	LOW	NO DMD	0.0	0.0 TO 5.00	5.00 TO 10.00	10.00 TO 20.00	20.00 TO 30.00	30.00 TO 50.00	> 50.00
I	265.45	365.00	219.00	1	0	0	0	0	0	0	3
II	232.27	273.75	182.50	1	0	0	0	0	0	0	3
III	286.79	365.00	0.0	0	1	0	0	0	0	0	3
TOT	263.61	312.86	0.0	0	1	0	0	0	0	0	3

IMPLEMENTATION



LIFE CYCLE COST TECHNIQUES

FREDA W. KURTZ

OPERATIONS RESEARCH ANALYST

AIR FORCE ACQUISITION LOGISTICS DIVISION

Freda W. Kurtz
Operations Research Analyst
Air Force Acquisition Logistics Division

INTRODUCTION

The importance of cost estimates in the evaluation process during the development and procurement of weapon systems is well-known. It is also true that life cycle cost estimates are a part of the decision-making exercise when operational plans, maintenance concepts, and support procedures are being determined. Cost management pervades all categories of management decisions including logistics capability.

REQUIREMENTS OF COST MODELS

Cost models must possess certain characteristics if they are to be of practical use to cost estimators and cost analysts and if the projections which they generate are to be of value to the decision-maker.

Cost models must be available for use within the time constraints imposed by the requirements of the need for the study.

Likewise, cost models must require only available data or data that may be obtained within the time limitations imposed on the study. As cost estimates are generated for the purpose of providing information about probable future costs, a cost analyst never has all the data which he or she would like to have.

Cost models must provide accurate estimates if they are to serve the purpose of helping the decision-makers. Misleading information is definitely of no benefit and may even be detrimental if it causes erroneous decisions to be made.

Cost models must be sensitive to the parameters or factors being investigated if they are to be helpful to the manager. For example, if a cost model contains only one basic algorithm for maintenance which is computed as a standard factor stated as a percentage of the flyaway cost of an airplane, that model cannot be used to differentiate between two-level and three-level maintenance concepts.

Cost models must be easily understood by top management if top managers are going to be willing to accept the estimates generated by the models. This does not necessarily mean that the top staff must understand the details surrounding every algorithm in the computer program. But, it does mean that the cost analyst must be able and willing to answer the questions which the managers ask. The cost analyst must answer honestly and concisely, and must be able to translate the jargon of the computer programmer into the vocabulary which is meaningful to the decision-maker.

Of course, in the military environment, the cost analyst must utilize methods which incorporate principles acceptable to higher levels of command.

In all likelihood, expert opinion was the life cycle cost tool first used by the early cost estimators. Expert opinion means that the cost analyst confers with the design engineers and the logisticians about the similarities and differences of the characteristics of a postulated system versus the characteristics of an existing system. The cost analyst then uses his experience and expertise to translate the statements of the experts into cost estimates.

Historical analogy is closely related to expert experience. When a cost analyst is assigned the task of preparing a cost estimate for a postulated system, he or she consults the historical costs of prior systems which are similar to the postulated system and uses the historical data to extrapolate the estimates for the new system. The use of historical analogy is increasingly hazardous as the postulated system contains characteristics which push the state-of-the-art into areas in which there are no existing systems and no valid historical data.

Parametric estimates are estimates which utilize historical data for the statistical development of estimating relationships or factors. The estimating relationships and factors are incorporated into equations. The equations, in turn, are usually incorporated into algorithms and computer programs. Parametric estimates are usually used during the early design of systems.

Engineering or build-up estimates are based on the collection of actual data from the early experience with a system. The early data might be the manufacturing data collected during the fabrication of the test items or it might be the operational data from the conduct of the test program. The actual data would be incorporated into the algorithms. Because actual data form the basis for engineering estimates, engineering or build-up type of models provide the most accurate method available to the cost analyst. The major deteriment limiting the use of this type of model is the requirement for actual data which are not available early in the design phase of the life cycle of a system.

APPLICATION OF ESTIMATING TECHNIQUES

The life cycle cost technique that is most appropriate for a cost analyst to use varies with the different phases in the life cycle of a weapon system.

A weapon system progresses from the conceptual phase into the demonstration/validation phase, then into full-scale engineering development, and finally into production which, of course, is followed by operation.

The kind of data which are available for the use of the cost analyst become more detailed and more accurate as the weapon system passes through the phases of the life cycle. The initial or early cost estimates must rely on gross relationships. Later it may be possible to obtain data which contain information by major cost category. When a system is in production, data are usually available by work break-down structure.

The distinction between the phases is expected to become blurred under the streamlined procedures being established by the new administration in Washington. The number of DSARC (Defense System Acquisition Review Council) formal procedural steps have been reduced.

However, it will still be necessary for a weapon system to pass through the sequential process of being conceptualized or designed, of being verified, of being determined by engineers to be feasible, and of being produced before it can become operational. Hence, it is expected that cost analysts will continue to be asked to prepare cost estimates on a recurring basis throughout the development and production process.

PARAMETRIC ESTIMATES

Parametric cost estimates are possible prior to the availability of detailed information concerning the engineering characteristics of proposed systems.

Parametric cost estimates make use of statistically derived relationships. The relationships are based on the historical cost of systems currently in the operating inventory which have the same basic characteristics as the postulated system. The slope of the cost trend lines are extrapolated into the future for increased performance associated with the postulated system.

Of course, the slope of the trend lines must be modified to reflect changes in technology, manufacturing processes, materials used, and other significant factors.

Parametric cost estimates are composed of cost factors and cost estimating relationships which are embodied in equations. Usually, the models are programmed for the computer. The programs for the majority of cost models are written in FORTRAN.

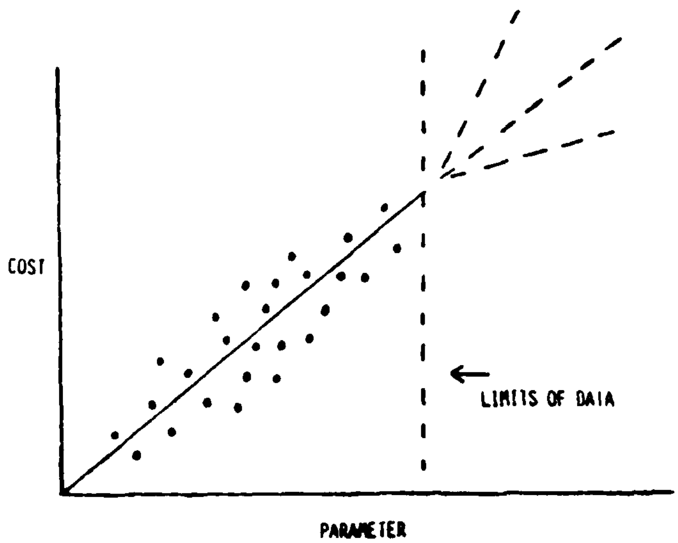
DEVELOPMENT OF COST ESTIMATING RELATIONSHIPS (CERs)

Cost estimating relationships are known as CERs. Sometimes the term is shortened to estimating relationships which are known as ERs.

The statistical procedure of regression analysis is used to determine cost estimating relationships between the dollar cost of a weapon system and the numerical value of an engineering or performance characteristic of the weapon system.

The significant engineering or performance characteristics must be determined before cost estimating relationships can be derived. This is an important step in the process as it is essential that the engineering or performance characteristic selected for analysis be important as a cost driver. That is, variations in the numerical index of the engineering or performance characteristic must be associated with changes in the cost of the system.

PROJECTING HISTORICAL DATA



The slope of the trend lines derived from historical data are valid only to the limits of the data involved. This means that the cost analyst must use judgment in making a decision about the slope of the trend line beyond the limits of the available data.

Three possible options are open to the cost analyst. The cost analyst may decide that the slope of the trend line should be accelerated, should continue at the same slope or should be decelerated.

In the first case, the cost analyst may have been given reliable information which indicates that the progress which has been occurring in the engineering parameter under consideration has approached a technological limitation. This may be interpreted to mean that any future advancement in the state-of-the-art concerning this particular parameter can only be achieved with great engineering effort. Such a situation would indicate that the slope of the trend line should be accelerated.

In the second case, the cost analyst may have reason to believe that technological progress will continue to be made at a steady rate and that the slope of the trend line will in the future, continue upward with the same slope as has occurred in the past.

In the third case, the cost analyst may have learned that the engineers and logisticians are anticipating an important technological breakthrough. This may lead the cost analyst to predict that the rate of increase in the trend line will be slowed to reflect the jump in the associated technology.

EXAMPLE OF CER

An extremely simple CER is one which relates the production cost of attack and fighter aircraft to a cost per pound of weight.

PRODUCTION COST = \$230 X WEIGHT IN POUNDS

The simplified CERs are also known as "rules of thumb." They do not contain the precision which is necessary for accurate cost estimates. However, in certain cases even such rough rules of thumb may provide order of magnitude information which is of some value.

DEVELOPMENT COST CER FOR RADAR SYSTEM

An example of a CER is the one shown for use in computing the development cost for radar systems.

$$LnC = 0.784 - 0.205\ LnA + 0.165D + 0.151\ LnP + 0.028S + 0.028SC + 1.370TD$$

C = Radar System Development Cost
A = Antenna Aperture
D = Degree of Development
P = Peak Power
S = Sensitivity
SC = Number of Special Circuits
TD = Type of Development

This CER requires input information about antenna aperture, degree of development, peak power, sensitivity, number of special circuits, and type of development. Information about part of these items can be obtained directly from radar engineers if all engineering design details have been established. However, information about at least one factor, namely degree of development, must be derived through a process of synthesizing past experience with an understanding of applicable radar technology and of the radar industry.

The level of accuracy of the cost estimates derived from CERs is directly related to the accuracy of the input values and to the validity of the relationships contained in the equations. In addition, it is essential that the factors selected for incorporation into the CER be the significant cost drivers for the system or component being studied.

ADVANTAGES AND DISADVANTAGES OF PARAMETRIC ESTIMATES

Parametric cost estimates have at least four major advantages:

a. Parametric cost estimates may be used early in the development process of weapon systems before detailed design information is available.

b. Parametric cost estimates are relatively easy to use, and parametric cost estimates can be generated within comparatively tight deadlines.

c. Parametric cost estimates are not subjective. This means that different cost analysts using the same model would obtain the same results.

d. Parametric cost estimates are developed by means of models which incorporate cost estimating relationships based on actual historical data.

Parametric cost estimates have at least three major disadvantages:

a. Parametric cost estimates are "will-cost" rather than "should-cost" estimates. They do not provide the decision-maker with information about what the cost of a system would be if optimum manufacturing and management procedures were utilized. They provide the decision-maker with information about the costs which will be experienced with a continuation of the past pattern of manufacturing and management procedures during the production of the new system.

b. Parametric cost estimates have limited trade-off application. The models cannot be used to provide comparative information of alternative systems or alternative logistics concepts when factors concerning the alternatives or concepts are not incorporated in the models.

c. Parametric cost estimates are based on actual experience. In some situations this is an advantage as was indicated above. However, it is a disadvantage in those cases when a cost analyst is trying to prepare estimates for an exotic new system which differs radically from past experience. In such cases, a cost estimate based on expert opinion would likely be more accurate than a cost estimate based on historical data of systems which are almost totally different from the postulated system.

ENGINEERING OR BUILD-UP ESTIMATES

Engineering or build-up estimates are appropriate to use when enough information becomes available to make their use possible.

Engineering estimates are based on the facts concerning the specific system for which cost estimates are being developed. This means that engineering estimates cannot be made for a postulated system during the early conceptualization of that system.

Engineering estimates provide a greater degree of accuracy than is usually true of parametric type estimates. The increased level of input data which is required for engineering cost models provide an increased degree of accuracy of the cost estimates generated by engineering type models in comparison with the lesser requirements for input data for parametric models which, in turn, are expected to provide less precision in the cost estimates generated.

Engineering or build-up estimates are based on the details of the specific design of the weapon system for which the estimates are being developed.

Engineering or build-up estimates require input data down to the lowest level of unit to be repaired. Engineering cost models generate cost estimates for the lowest level of unit to be repaired. Parametric cost models, on the other hand, usually provide information only down to the major subsystem level.

Engineering cost estimating models require information about the specific maintenance plan to be used for the subsystem being considered.

Engineering or build-up estimates are based on specific reliability data. If the reliability data are to be accurate, they must be collected during test and operation of the system. Of course, such data are not available during the conceptualization of a postulated system.

Engineering or build-up estimates are based on specific maintenance labor manhour requirements and labor rates. This means that it is necessary to have accurate data on which to base model input values if the cost estimates generated by the model are to be accurate.

Engineering or build-up estimates also require input information concerning the specific spare parts projections to be required by the subsystem being studied.

Engineering or build-up estimates should be refined by the use of feedback data generated from the test and operation of the weapon system for which costs are being generated. As more test or operating experience is gained, more accurate data become available. More accurate data, of course, will provide more accurate cost estimates.

ADVANTAGES AND DISADVANTAGES OF ENGINEERING ESTIMATES

Engineering or build-up cost estimates have at least four advantages:

a. Engineering or build-up cost estimates may be used to provide detailed trade-off studies at the system level.

b. Engineering or build-up cost estimates may also be used for trade-offs at the subsystem level.

c. Engineering or build-up estimates may also be used to provide cost comparisons of the efficiency of different maintenance concepts.

d. Engineering or build-up cost estimates provide a high degree of accuracy.

Engineering or build-up cost estimates have at least two major disadvantages:

a. Engineering or build-up cost models cannot be used during the early phases of the life cycle of a weapon system.

b. Engineering or build-up cost models require a great amount of data. This means that the models cannot be used until the data are available. It also means that the cost analyst must perform the additional work which is associated with the handling and utilization of the data.

Section IV

Session B Papers

Moderator: Lt Col Joseph M. Campbell
Logistics Concepts Division
Directorate of Logistics Plans
and Programs
DCS/Logistics and Engineering
Headquarters, USAF

Papers are in order of presentation during LOGCAS 82. Refer to pages I-12 and 13, for presentation order. Not all presentations have papers associated with them.

TODAY'S SYSTEM

- WORLDWIDE COMPUTATION
    - CAPABILITY ONLY ONE WAR
- MONTHLY COMPUTATION
- SINGLE INDENTURE LEVEL
- ONE SET OF FAILURE RATES/PIPELINES
- LIMITED RESOURCE ALLOCATION TOOLS

MODEL PURPOSE/APPLICATION

- DETERMINE WARTIME REQUIREMENTS
  - POM, BUDGET, BUY
  - WHAT IF QUESTIONS
- ALLOCATE SCARCE RESOURCES
  - DOLLARS
  - ASSETS
- DETERMINE WARTIME DEPOT MAINTENANCE REQUIREMENTS

WARTIME ASSESSMENT

AND

REQUIREMENTS SIMULATION

(WARS)

MODEL

BRIEFER: DIANN LAWSON
RESEARCH AND ANALYSIS BRANCH
AFLC/LORAA

AFLC - Lifeline of the Aerospace Team

The TAC PACERS implementation schedule has a target of 15 April 1982 for completing the on-line testing for the first mission design series selected. The computer programming is progressing on schedule and the target objective date should be met.

WRSK SERIAL #: F015A0T2401   SRAN: XX TFW   DATE: 15 FEB 82

NSN	NOUN	EXPECTED SORTIES	MAX NMCS AIRCRAFT	AUTH QTY	ALLOCATED O/H QTY
1630015855912	MLG WHEEL	1015	9	45	20
5841010588180	RADAR PROCESSOR	1050	7	8	2
5841010587297	CIRCUIT CARD	1050	7	7	1
5841010587295	CIRCUIT CARD	1060	6	3	0

Figure 7 - Stratified Pacing Parts Shortages Report

OTHER PARTS SHORTAGE

WRSK SERIAL #: F015A0T2401   SRAN: XX TFW   DATE: 15 FEB 82

NSN	NOUN	AUTH QTY	ALLOCATED O/H QTY
1560001003763	PANEL	2	1
2840005341824PT	SEAL ASSY	21	18
[illegible]28010121038	RT UNIT	5	4
5841000791501	AMPLIFIER	3	1

Figure 8 - Other Parts Shortage Report

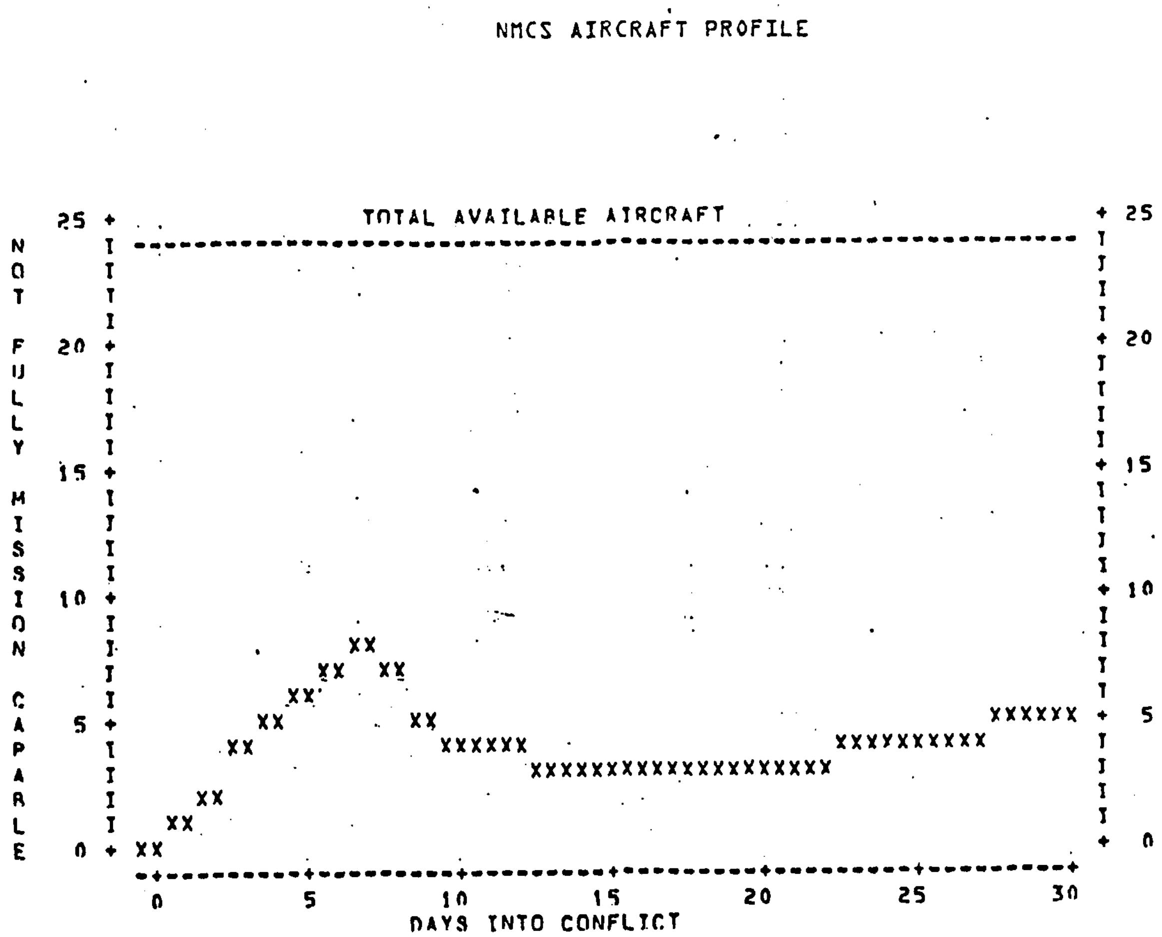


Figure 6 - NMCS Aircraft Profile Report

Figures 7 and 8 are reports designed primarily for the functional manager. The information in Figure 7 represents a rank-ordered listing of parts shortages which are limiting capability. This report is intended to allow the functional manager, on a management by exception basis, to focus attention on the most important items. The report in Figure 8 is an optional report which provides a list of all other parts in the WRSK which have shortages.

The philosophy used in designing the output reports was to keep them simple, direct, and sized so as to fit on a standard vugraph. The first two reports shown in figures 5 and 6 were designed for the operational commander and his staff for the purpose of giving them insight into how limiting parts shortages may be on the capability to accomplish the operational tasking. As shown in Figure 5 the expected sorties are printed in enlarged numbers with the key input parameters below. Figure 6 is a plot over a 30 day time period of the expected number of aircraft that would not be fully mission capable because of missing parts.

EXPECTED SORTIES REPORT

```
X   XXXX   X  XXXXXX    XXXX   XXX   XXXX   XXXXX  X  XXXXX   XXXX
X  X    X  X  X        X      X   X  X   X    X    X  X      X
X  X    X  X  XXXXX     XXX   X   X  XXXX     X    X  XXX     XXX
X  X    X  X       X       X  X   X  X X      X    X  X          X
X  X    X  X       X       X  X   X  X  X     X    X  X          X
X   XXXX   X  XXXXX    XXXX    XXX   X   X    X    X  XXXXX  XXXX
```

KEY INPUT PARAMETERS:
  -3.0 MAXIMUM SORTIES/AIRCRAFT/DAY FOR AIRCRAFT NOT OUT FOR SUPPLY
  -30 DAY SORTIE TASKING: 1125 SORTIES
  -WRSK SERIAL #: F015A0T2401

Figure 5 - Expected Sorties Report

TAC PACERS IMPLEMENTATION

The realization of the Dyna-TAB capability coincided with the implementation of the Combat Supply Management System (CSMS) to make it feasible and practical to develop a "real time" unit level WRSK capability assessment system. This system has been named TAC PACERS (Peacetime Assessment of the Combat Effectiveness of Reparable Spares).

The automated concept of the system is depicted by the flow chart in Figure 4. The CSMS is a centralized data base which provides, among other things, the on-hand spares information associated with every WRSK in the command. This information is residence in the MAJCOM WWMCCS computer (i.e., Honeywell 6000) and the information is updated on a daily basis. The TAC PACERS implementation concept interfaces the on-hand spares information from CSMS with the tables produced by Dyna-TAB to generate assessment reports.

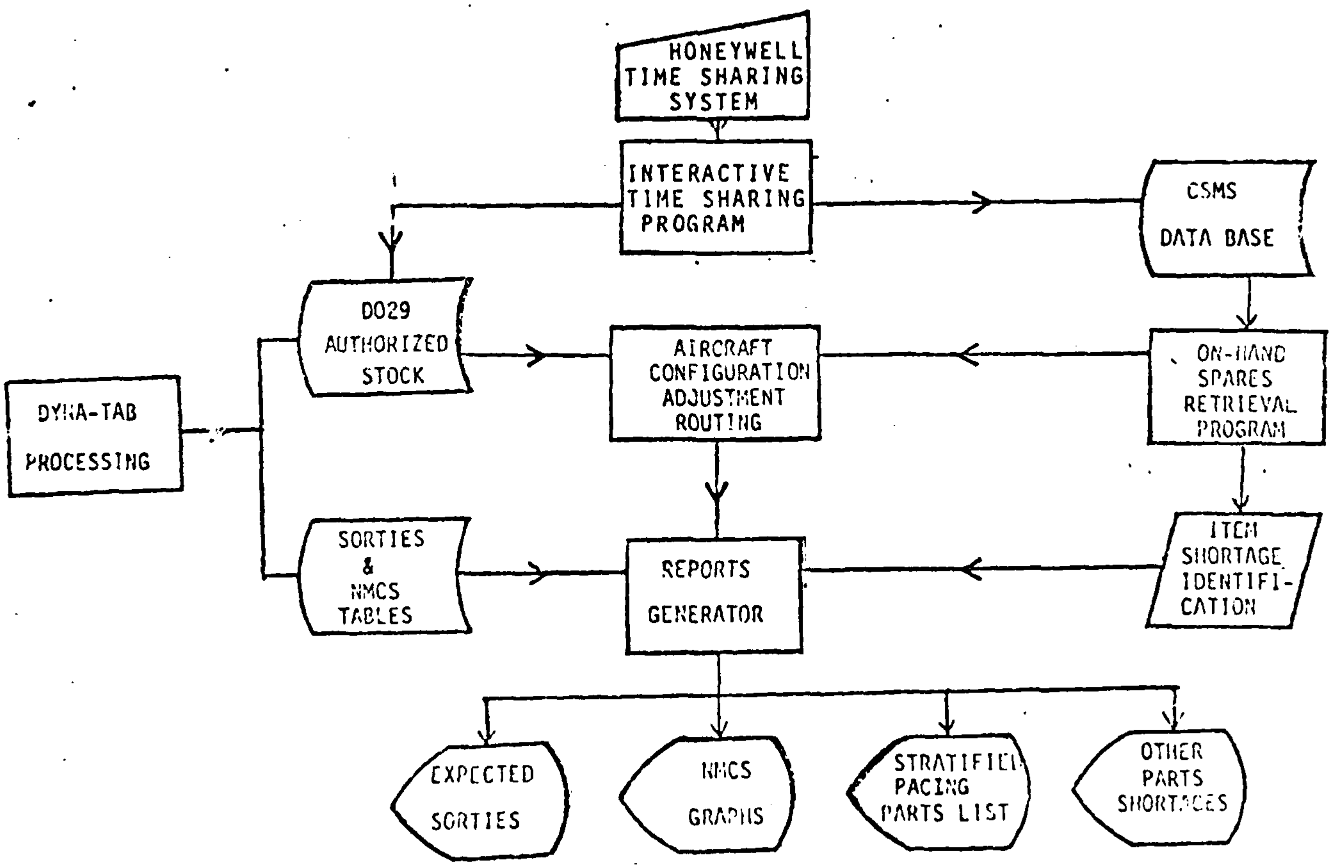


Figure 4 - TAC PACERS Automated Concept

DYNA-TAB CHARACTERISTICS

Figure 3 presents an overview of the Dyna-TAB process. Keeping in mind that it was designed for a somewhat narrow application, it takes advantage of the Dyna-METRIC capabilities. This is true from the standpoint of using much of the internal mathematical logic from Dyna-METRIC and using the identical input data formats. One technical difference, however, is that the Dyna-TAB logic insures that parts consumption and aircraft flying hour accomplishments are kept in balance. This is in contrast to Dyna-METRIC where the logic causes parts to be demanded based on the input flying hour program objective rather than the flying hour accomplishment.

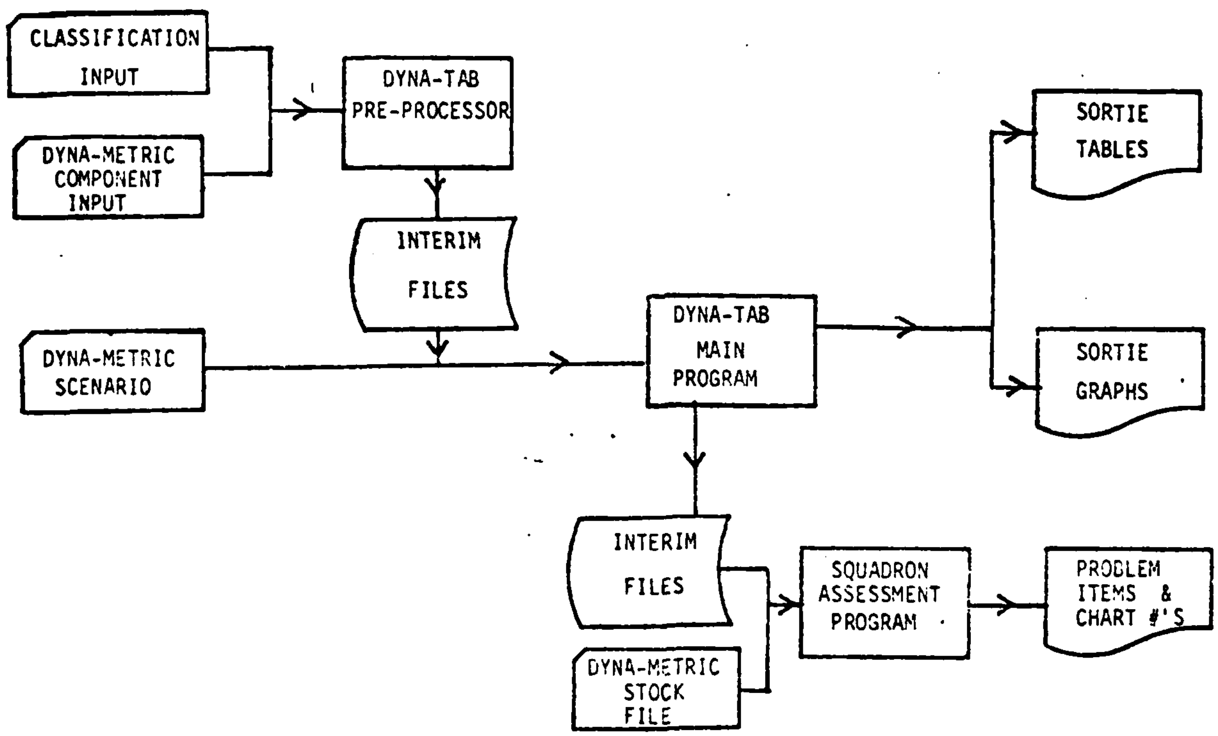


Figure 3 - Overview Dyna-TAB Process

LRU: RADAR ANALOG PROCESSOR WUC: 74FS0 NSN: 5841 01 058 8180

SRU: WIDE BAND AMPLIFIER WUC: 74FSG NSN: 5841 01 015 6232

SRU ON-HAND STOCK LEVEL	LRU ON-HAND STOCK LEVEL 0	1	2	3	4
0	690	780	880	970	1050
1	770	865	960	1050	1125
2	840	940	1035	1120	1200
3	895	1000	1095	1185	1260
4	945	1050	1145	1235	1295

FACTORS
24 PAA SQUADRON
3.0 MAX SORTIES/ACFT/DAY
30 DAYS FLYING

Figure 1 - Sorties Versus On-Hand Spares Level

LRU: RADAR ANALOG PROCESSOR WUC: 74FS0 NSN: 5841 01 058 8180

SRU: WIDE BAND AMPLIFIER WUC: 74FSG NSN: 5841 00 149 1396

SRU ON-HAND STOCK LEVEL	LRU ON-HAND STOCK LEVEL 0	1	2	3	4
0	16	15	14	13	12
1	15	14	13	12	11
2	14	13	12	11	10
3	13	12	11	10	9
4	12	11	10	9	8

FACTORS
24 PAA SQUADRON
3.0 MAX SORTIES/ACFT/DAY
30 DAYS FLYING

Figure 2 - NMCS Aircraft Versus On-Hand Spares Level

DYNA-METRIC FOUNDATIONS

Dyna-METRIC is a relatively flexible and easy to use spares analysis model. Through the accomplishment of various WRSK spares analyses, three primary concepts emerged that became the foundations of the approach. First was the recognition and the establishment of confidence in the ability to use "sorties flown" and "Not Mission Capable Supply" (NMCS) as measures of merit for WRSK readiness/sustainability assessments.

Second was the development of the concept of potential pacing spare parts identification. This concept and subsequent techniques allow the range of items in a WRSK to be segregated into those items that will potentially drive the operational capability and are therefore important to address explicitly in the capability assessment process and those items which will not drive airframe availability and can be treated implicitly.

The third foundation concerned the capability to develop for the potential pacing items that needed to be explicitly addressed tables which quantified the expected sorties and NMCS aircraft in relation to the possible range of on-hand stock. An example of a sortie table is shown in Figure 1 while a NMCS aircraft table is illustrated in Figure 2.

Although these foundations were solid and the utility of Dyna-METRIC well recognized, the specific application of using Dyna-METRIC to build large numbers of these types of tables was cumbersome and inefficient in terms of resources and calendar time. Therefore, Dyna-TAB was conceived and developed as a derivative of Dyna-METRIC for the specific purpose of generating sortie and NMCS aircraft tables and graphs.

A "REAL TIME" UNIT LEVEL WRSK CAPABILITY ASSESSMENT SYSTEM

BACKGROUND

Within the USAF Logistics Capability Assessment community it has been generally recognized that good methods relating spares shortages to operational impacts have not generally been available. The percent fill of a War Reserve Spares Kit (WRSK) has been routinely used as an indicator of operational capability in our status reporting systems. However, this indicator concerned with the percent of authorized stock that is on-hand in the WRSK has a shortcoming in that it does not recognize the difference in the criticality or worth of various parts as they relate to each other. Some logistics spares analysis efforts using the Dyna-METRIC model gave some insights into a different approach that represented a significant improvement over the percent fill indicator. This situation lead to establishing a firm management objective to devise a new method of relating on-hand spares quantities to indicators of operational readiness/sustainability.

The accomplishment of the objective was realized through an evolutionary process whereby the Dyna-METRIC model provided the early insights and established the solid technical foundations that determined the approach; a new computer model called Dyna-TAB was developed by the Rand Corporation to facilitate accomplishing the major technical tasks in an efficient manner; and the TAC implementation design concept matured to allow an efficient and responsive method of exercising the system. The highlights of each of the aspects of the evolution will be discussed.

A "REAL TIME" UNIT LEVEL WRSK CAPABILITY ASSESSMENT SYSTEM

BY

RONALD W. CLARKE, LT COL, USAF

MARCH 1982

HQ TACTICAL AIR COMMAND
DEPUTY CHIEF OF STAFF LOGISTICS
DIRECTORATE OF LOGISTICS ANALYSIS
LANGLEY AFB VA 23665

An Analysis Model

of Sortie Generation

at the Flight Line

Paper prepared by Dr. Richard Hillestad
& Brian Leverich

Presented by Dr. Mort Berman
The RAND Corporation

Paper Not Included.

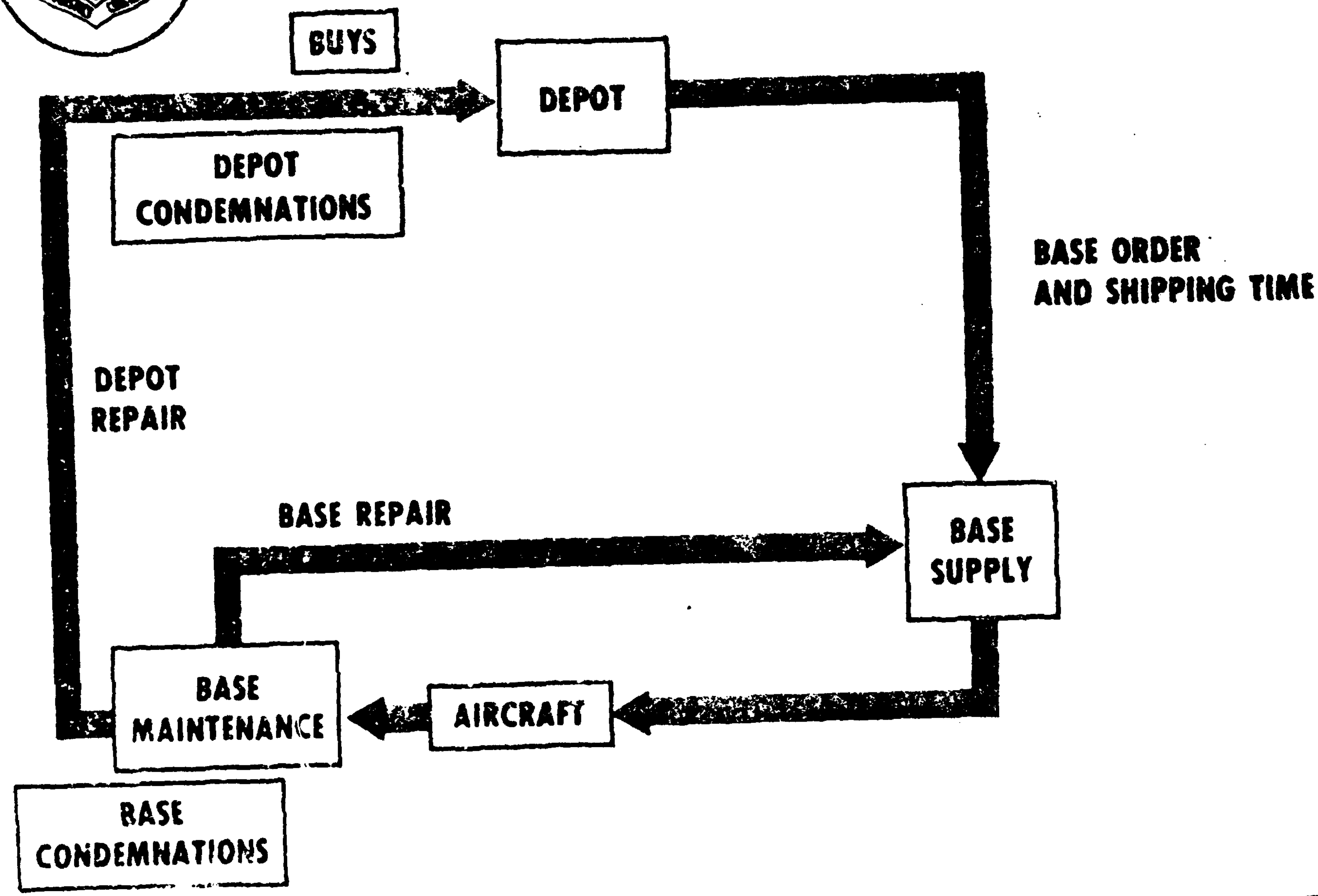
WARS

- SQUADRON LEVEL COMPUTATION
  - MULTIPLE D-DAYS
  - MULTIPLE SCENARIOS
- DAILY COMPUTATION
- FOUR LEVELS OF INDENTURE
  - ENGINE/MODULE/LRU/SRU
- PEACETIME AND WARTIME RATES/PIPELINES
- WRM OPERATIONAL PRIORITY MATRIX
  - ALLOCATE ASSETS
  - BUY WRM

WARS
CONCEPT

- SIMULATE WARTIME CONDITIONS
    - FLYING HOUR SURGE
    - WARTIME DEPLOYMENT
    - WARTIME CONDITIONS FOR WAR SUPPORT PERIOD
- FOR ALL SQUADRONS

WARS CONCEPT: PIPELINES



WRM OPERATIONAL PRIORITY MATRIX

- OPERATORS/LOGISTICIANS - NOV 1979
- PRIORITIZED FORCE PACKAGES
  - ACHIEVABLE DAYS OF SUPPORT INCREMENTS
  - COMPOSITION OF FORCE PACKAGE

AIR FORCE OPERATIONAL PRIORITY MATRIX
(BY SQUADRON PRIORITY)

WITHIN CATEGORY PRIORITY	PRIORITY CATEGORY/ SQUADRON	A	B
1	PAF	7 DAYS	10 DAYS
	F-4(18)		
	F-15(24)		
	AFE	10 DAYS	15 DAYS
	F-4(18)		
	F-15(24)		
	A-10(18)		
2	RDF	10 DAYS	23 DAYS
- BY SQUADRON SHOWS CUMMULATIVE WRM & REQMTS AND DAYS SUPPORT - - ORDER OF PRIORITY A1, A2, B1, B2, ETC.			
3	C-5	30 DAYS	45 DAYS
	C-141	30 DAYS	90 DAYS

AIR FORCE USERS

- REQUIREMENTS INFORMATION
  - ITEM/SYSTEM MANAGERS
  - ALC AND AFLC RESOURCE MANAGERS
  - HQ USAF
- CAPABILITY ASSESSMENTS
  - SYSTEM MANAGERS
  - MAJCOMS
  - AFLC
  - HQ USAF
- DEPOT MAINTENANCE WORKLOAD
  - AFLC AND ALC
  - MAINTENANCE AND MATERIEL MANAGEMENT

SUMMARY

WARS CAPABILITIES

- DEVELOP REQUIREMENTS FOR POM, BUDGET AND BUY
- ALLOCATE RESOURCES
- DETERMINE DEPOT MAINTENANCE REPAIR REQUIREMENTS

SLIDE 1

SLIDE 1 - WARS MODEL

THE WARTIME ASSESSMENT & REQUIREMENTS SIMULATION (WARS) MODEL REPRESENTS A NEW CONCEPT IN REQUIREMENTS DETERMINATION FOR BUDGET PROGRAM 1500 RECOVERABLE AIRCRAFT SPARES. RECOVERABLE SPARES ARE THOSE THAT ARE REMOVED FROM THE AIRCRAFT, REPAIRED AND REPLACED BACK ON THE AIRCRAFT.

SLIDE 2

SLIDE 2 - OBJECTIVE (SLIDE OMITTED)

THE OBJECTIVE OF THE WARTIME ASSESSMENT AND REQUIREMENTS SIMULATION MODEL IS TO PROVIDE MORE FIGHTING CAPABILITY THROUGH AN IMPROVED AIR FORCE REQUIREMENTS DETERMINATION PROCESS. IT IS AN AIR FORCE PROCESS BECAUSE THE MODEL INPUTS ARE PROVIDED FROM ALL LEVELS OF THE AIR FORCE AND OUTPUTS WILL BE USED WIDELY THROUGHOUT THE AIR FORCE.

SLIDE 3

SLIDE 3 - OVERVIEW (SLIDE OMITTED)

THE BRIEFING COVERS THESE TOPICS:

SLIDE 4

SLIDE 4 - MODEL PURPOSE/APPLICATION

THE WARS MODEL WILL ACCOMPLISH THREE MAJOR PURPOSES. FIRST IT COMPUTES WARTIME BUDGET PROGRAM 1500 RECOVERABLE AIRCRAFT SPARES REQUIRED FOR WAR. WARS ALLOWS AFLC TO BECOME A MORE ACTIVE PCM PLAYER BECAUSE OF ITS CAPABILITY TO COMPUTE MULTIPLE YEAR REQUIREMENTS AND TO ANSWER "WHAT IF?" QUESTIONS. IT ALSO PROVIDES BUDGET REQUIREMENTS ALONG WITH ACTUAL STOCK NUMBER BUY REQUIRMENTS. ANOTHER MAJOR FUNCTION IS THE AUTOMATED ABILITY TO ALLOCATE "BUY" DOLLARS AMONG THE AIR LOGISTICS CENTERS AND ASSETS AMONG THE MAJOR COMMANDS. THE MODEL WILL PROVIDE THE FIRST EVER AUTOMATED CAPABILITY TO COMPUTE WARTIME REPAIR REQUIREMENTS. MAINTENANCE CAN USE THIS DATA TO PLAN WARTIME DEPOT REPAIR REQUIREMENTS WITH AFLC MAINTENANCE MANNING, FACILITIES AND EQUIPMENT REQUIREMENTS. ALSO, IF MAINTENANCE HAS A MANPOWER OR EQUIPMENT SHORTFALL, THE MODEL CAN RECOMPUTE REQUIREMENTS BASED ON PLANNED MAINTENANCE REPAIR CAPABILITIES. IN SUMMARY, THE MODEL PROVIDES MULTIPLE CAPABILITIES CURRENTLY LACKING IN TODAY'S SYSTEMS.

SLIDE 5

SLIDES 5 - TODAY'S SYSTEM & 6 - WARS

THE WARS MODEL ELIMINATES MANY OF THE DEFICIENCIES IN TODAY'S RECOVERABLE ITEM COMPUTATIONAL SYSTEM PLUS PROVIDES MANY CAPABILITIES THAT WERE NOT REQUIRED BY TODAY'S SYSTEM AS FEW AS TWO OR THREE YEARS AGO.

ONE LIMITATION OF THE CURRENT SYSTEM IS ITS ABILITY TO COMPUTE ONLY ONE WAR AND THEN AT A WORLDWIDE LEVEL. THE WARS MODEL WILL COMPUTE REQUIREMENTS AT A

SQUADRON LEVEL PLUS IT WILL COMPUTE MULTIPLE D-DAY PERIODS. COMPUTER RUNNING TIME OF THE MODEL IS REDUCED SO GREATLY COMPARED TO TODAY'S SYSTEM, THAT MULTIPLE SCENARIOS CAN BE INPUT TO COMPUTE REQUIREMENTS OR TO ASSESS CAPABILITIES.

A SECOND MAJOR LIMITATION OF TODAY'S SYSTEM IS A MONTHLY COMPUTATION. QUARTERLY PROGRAMS ARE DIVIDED INTO MONTHLY PROGRAMS. THE MONTHLY PROGRAMS ARE FURTHER DIVIDED SO THAT THE PROGRAM FOR ANY ONE DAY IS THE MONTH'S PROGRAM DIVIDED BY 30 DAYS. IN WARS DAILY REQUIREMENTS WILL BE COMPUTED BASED ON ACTUAL--NOT AVERAGE--PLANNED DAILY FLYING HOUR PROGRAMS. THIS DAILY REQUIREMENT WILL CAPTURE THE DYNAMIC IMPACT ON THE PIPELINES OF THE CHANGING PROGRAMS -PEACE TO SURGE (WAR) TO SUSTAINED (WAR). THIS IS ESSENTIAL TO COMPUTING ACCURATE REQUIREMENTS.
SLIDES 5 & 6 (CONTINUED)

A THIRD LIMITATION OF TODAY'S SYSTEM IS ITS LACK OF ITEM INDENTURE RELATIONSHIP. THE AVAILABILITY OF ANY LINE REPLACEMENT UNIT (LRU) DEPENDS UPON THE AVAILABILITY OF A SHOP REPLACEMENT UNIT (SRU) TO FIX THE LRU. THE WARS MODEL WILL RECOGNIZE FOUR LEVELS OF INDENTURE RELATION: (1) SRU TO LRU, (2) LRU TO THE ENGINE MODULE, ENGINE OR AIRCRAFT, (3) THE ENGINE MODULE TO THE ENGINE AND (4) THE ENGINE TO THE AIRCRAFT. THIS CAPABILITY ENSURES SUFFICIENT LOWER INDENTURE ITEMS ARE IDENTIFIED TO MEET THE REPAIR NEEDS OF THE HIGHER INDENTURE ITEM. THIS CONTINUES UP THE "INDENTURE CHAIN" TO ENSURE THE SPECIFIED AIRCRAFT AVAILABILITY GOAL IS ACHIEVED.

THE FOURTH LIMITATION SHOWN ON THE SLIDE IS THE USE OF ONLY ONE SET OF FAILURE RATES OR FACTORS UPON WHICH TO COMPUTE WARTIME REQUIREMENTS. THE MODEL HAS THE CAPABILITY TO USE THREE SEPARATE RATES OR FACTORS -- PEACETIME, INITIAL WAR, SUSTAINED WAR. EXPERIENCE GAINED FROM WRM AIRCRAFT REVIEWS SHOW THAT THESE RATES AND FACTORS DO EXIST. WITH WARS THE CAPABILITY EXISTS TO USE THOSE FACTORS.

THE LAST MAJOR ADVANTAGE OF THE WARS MODEL OVER TODAYS SYSTEMS, IS THE ABILITY TO USE THE MODEL TO ALLOCATE DOLLARS AMONG WEAPON SYSTEMS WHENEVER THE BUDGET DOLLARS ARE INSUFFICIENT TO MEET REQUIREMENTS AND TO DISTRIBUTE ASSETS AMONG THE MAJOR COMMANDS. BOTH OF THESE FUNCTIONS WILL USE THE AIR FORCE OPERATIONAL PRIORITY MATRIX AS THE MEANS OF ALLOCATING RESOURCES.

EACH OF THESE CAPABILITIES BEING BUILT INTO THE WARS MODEL ARE DESIGNED TO IMPROVE THE REQUIREMENTS DETERMINATION PROCESS AND PROVIDE THE AIR FORCE WITH MORE FIGHTING CAPABILITY.

SLIDE 7

SLIDE 7 - WARS CONCEPT

WE TRANSITION HERE FROM EXPLAINING THE CAPABILITIES OF THE MODEL, TO PROVIDING A CONCEPTUAL UNDERSTANDING OF HOW THOSE CAPABILITIES ARE ACHIEVED. THE CONCEPT USED IN WARS IS QUITE SIMPLE -- MODEL OR SIMULATE THE PIPELINES AS TIME PROGRESSES FROM PEACETIME INTO THE INITIAL WARTIME TRANSITION PERIOD AND THEN INTO THE SUSTAINED WARTIME PERIOD. MODEL THOSE PIPELINES AT THE SQUADRON LEVEL AND THRU THE DURATION OF TIME PERIODS (YEARS) FOR WHICH PROGRAMS EXIST. BASICALLY, THIS MEANS FROM ASSET "AS OF" DATE THROUGH THE POM PERIODS. THE NEXT SLIDE DEPICTS A SIMPLIFIED VIEW OF THE PIPELINES AS THEY EXIST TODAY.

SLIDE 8

SLIDE 8 - PIPELINES

CONCEPTUALLY, AIRCRAFT RECOVERABLE SPARES CAN BE THOUGHT OF A CYCLING THROUGH AS CLOSED SYSTEM. ITEMS ON AN AIRCRAFT FAIL DUE TO USAGE. MAINTENANCE PERSONNEL REMOVE THE FAILED ITEM AND REPLACE IT WITH A SERVICEABLE ONE. BASE MAINTENANCE EXAMINES THE FAILED ITEM AND REPAIRS IT IF THEY CAN. IF REPAIRED, THE ITEM IS RETURNED TO BASE SUPPLY TO SATISFY ANOTHER DEMAND. IF BASE MAINTENANCE LACKS THE CAPABILITY TO REPAIR THE FAILED ITEM, THEY SEND IT TO THE DEPOT FOR REPAIR. THE DEPOT THEN REPAIRS IT AND HOLDS IT UNTIL REQUISITIONED BY A USER. NOTE, THIS IS NOT A TRUE CLOSED SYSTEM. ITEMS CAN BE CONDEMNED--THROWN AWAY--AT THE BASE OR THE DEPOT. THESE CONDEMNATIONS ARE REPLACED THROUGH REPLACEMENT BUYS. IN PEACETIME, THESE PIPELINES ARE QUITE STABLE OR STEADY. THE TERM USED TO OFTEN TIME DESCRIBED THIS CONDITION IS STEADY_STATE, A TERM APPLIED TO OUR CURRENT RECOVERABLE SPARES SYSTEM. LET'S CONSIDER SOME OF THE THINGS THAT IMPACT THESE PIPELINES IN WARTIME SITUATION. FLYING HOUR PROGRAMS GO FROM A PEACETIME RATE TO A SURGE WARTIME RATE TO A SUSTAINED WARTIME RATE. FOR A PERIOD OF TIME NO AIRLIFT IS AVAILABLE TO SHIP SERVICEABLE AND UNSERVICEABLE PARTS BETWEEN CONUS AND THE WAR ZONE. ALSO MANY SQUADRONS DEPLOY INITIALLY WITHOUT A REPAIR CAPABILITY.

FROM THESE FEW EXAMPLES, IT IS OBVIOUS THAT THE WARTIME PIPELINES ARE DEFINITELY NOT "STEADY STATE."

TO CAPTURE THE DYNAMICS OF THE WARTIME PIPELINES, THE WARS MODEL COMPUTES A DAILY REQUIREMENT. IT USES DAILY FLYING HOUR PROGRAMS DEVELOPED AT HQ USAF AND APPROVED FOR PLANNING PURPOSES. WARTIME FACTORS AND DEMAND RATES ARE DEVELOPED AT WRM READINESS REVIEWS ATTENDED BY THE AFLC PERSONNEL AS WELL AS USING COMMAND MAINTENANCE AND SUPPLY PERSONNEL. HQ USAF APPROVED WARTIME RESUPPLY FACTORS ARE ALSO USED IN THE MODEL. THE RESULT OF ALL THIS IS A MUCH MORE REFINED WARTIME REQUIREMENTS THAN HAS EVER BEFORE BEEN DEVELOPED.

SLIDE 9

SLIDE 9 - WRM OPERATIONAL PRIORITY MATRIX

ANOTHER INPUT INTO THE WARS MODEL IS THE HQ USAF WRM OPERATIONAL PRIORITY MATRIX. THE MATRIX IS THE TOOL BY WHICH THE OPERATORS TELL THE LOGISTICIAN HOW TO PRIORITIZE THE SPARES BUYS AND ASSET DISTRIBUTION. IT IS DESIGNED TO ACHIEVE A SUPPORT CAPABILITY FOR A SPECIFIC FORCE FOR A SPECIFIC INCREMENT OF TIME. THE NEXT SLIDE SHOWS THE FORMAT OF THE MATRIX.

SLIDE 10

SLIDE 10 - AIR FORCE OPERATIONAL PRIORITY MATRIX

THE MATRIX DIVIDES FORCE PACKAGES INTO PRIORITY CATEGORIES. ASSOCIATED WITH EACH OF THOSE CATEGORIES IS A FORCE MADE UP OF SPECIFIC SQUADRONS. COLUMNS A AND B THEN SHOW THE INCREMENTAL APPROACH TO BUILDING A FULL WARTIME CAPABILITY. TO BUILD THOSE CAPABILITIES, FIRST THE REQUIREMENTS OF COLUMN A, PRIORITY CATEGORY 1, IS DEVELOPED. THEN COLUMN A, CATEGORY 2, IS DEVELOPED FOLLOWED BY COLUMN A, CATEGORY 3. FROM THESE, THE CAPABILITY OF THE CATEGORY 1 FORCE IS EXTENDED AS SHOWN IN BLOCK B1, THEREAFTER CAPABILITIES FOR B2, B3, ETC. ARE DEVELOPED UNTIL A FULL WARTIME CAPABILITY IS DEVELOPED FOR ALL FORCES. (NOTE: THE PRIORITY IS EQUAL FOR ALL FORCES IN A GIVEN BLOCK.)

SLIDE 11

SLIDE 11 - AIR FORCE USERS

THE WARS MODEL WILL HAVE OUTPUT PRODUCTS USED BY MANY PEOPLE AT MANY LEVELS WITHIN THE AIR FORCE. IT WILL IDENTIFY REQUIREMENTS INFORMATION TO BE USED BY ITEM MANAGERS IN BUYING SPARES. IT WILL ALSO BE USED BY ALC, AFLC AND HQ USAF IN POM AND BUDGET DEVELOPMENTS. THE CAPABILITIES ASSESSMENTS CAN BE USED BY WEAPON SYSTEM MANAGERS AS WELL AS USING COMMAND, AFLC AND AIR STAFF LEVELS. MAINTENANCE PERSONNEL CAN USE THE REPAIR REQUIREMENTS CAPABILITY TO PLAN WARTIME MANNING AND EQUIPMENT.

SLIDE 12

SLIDE 12 - APPROACH TO BUILDING WARS (SLIDE OMITTED)

THE WARS MODEL DEVELOPMENT WAS CONTRACTED TO DETERMINE IF THE DEVELOPED CONCEPTS CAN BE INCORPORATED SUCCESSFULLY INTO AN OPERATIONAL MODEL. ALSO, THE CONTRACT SETS UP A PHASED APPROACH TO BUILDING THE TOTAL MODEL CAPABILITY. THE FIRST CAPABILITY IS THE DETERMINATION OF THE BUY QUANTITY OF RECOVERABLE SPARES NEEDED TO MEET WARTIME MISSION REQUIREMENTS. SUBSEQUENT PHASES OR INCREMENTS WILL DEVELOP THE CAPABILITY ASSESSMENTS, POM AND BUDGET NEEDS, AND WARTIME DEPOT MAINTENANCE REPAIR REQUIREMENTS. DATES TO COMPLETE EACH PHASE ARE SHOWN ON THE SLIDE. LATER DEVELOPMENTS MAY INCORPORATE OTHER REQUIREMENTS SUCH AS EOQ ITEMS, OTHER RECOVERABLE SPARES, COMMUNICATIONS AND ELECTRONIC EQUIPMENT AND THE EQUIPMENT.

SLIDE 13

SLIDE 13 - SUMMARY

IN SUMMARY, THE WARS MODEL WILL PROVIDE A MUCH IMPROVED WARTIME COMPUTATION. AFLC WILL BECOME AN IMPROVED POM PLAYER. WARTIME REQUIREMENTS WILL BE A REFLECTION OF WARTIME FACTORS AND PLANNING ASSUMPTIONS--NOT JUST AN EXTENSION OF PEACETIME FACTORS. ALLOCATION OF DOLLARS AND ASSETS WILL BE IN ACCORDANCE WITH WARTIME PRIORITIES ESTABLISHED BY THE AIR STAFF. MAINTENANCE LIMITATIONS WILL BE DIRECTLY LINKED TO SPARES BUY REQUIREMENTS. ALL OF THIS IS PART OF THE OVERALL ACTIONS NOW UNDERWAY TO IMPROVE THE AIR FORCE REQUIREMENTS DETERMINATION PROCESS.

WD No. WD-1461-AF

Copy No.

Contract No.

Special Instructions

WORKING DRAFT

DESIGN AND CAPABILITIES OF Dyna-TAB

Manuel J. Carrillo

March 1982

WD-1461-AF

Prepared For United States Air Force

Rand
SANTA MONICA, CA 90406

78 (Rev 10/80)

PREFACE

This report documents a briefing on the Rand Dyna-TAB model presented by the author at the 1982 USAF Logistics Capability Assessment Symposium held at the Air Force Academy in Colorado Springs in March. This model was developed in response to a request of the DCS/Logistics, Tactical Air Command as an input to the TAC-PACER readiness assessment system. Other research was carried out under the Concept Development and Project Formulation project in the Project AIR FORCE Resource Management Program.

DESIGN AND CAPABILITIES OF Dyna-TAB

Manuel J. Carrillo
The Rand Corporation
March 1982

I. INTRODUCTION

Dyna-TAB is a dynamic analytic model embedded in the TAC-PACERS management system where it serves as its capability assessment tool. TAC-PACERS is described here only insofar as it helps define the design requirements of Dyna-TAB. Lieutenant Colonel Ronald Clarke [1] describes the overall TAC-PACERS management system concept and describes its future use. This paper describes the mathematical and empirical foundations of the Dyna-TAB model.

TAC-PACERS arose from the need to help wing commanders and other base level managers estimate the wartime operational capability of each squadron deploying with the on-hand stock levels of its War Reserve Spares Kit (WRSK). If the WRSK were less than full, squadron wartime capability might fall short of planned operational goals. The currently used base level measure of WRSK status (percent fill), cannot forecast how stock shortages might degrade wartime aircraft availability and sorties; neither can it identify which components will most constrain those two measures of squadron capability. TAC-PACERS will forecast wartime capability in those terms, and it will identify and rank components whose shortages may degrade that capability. Base level managers can use that information to identify local recovery actions (such as prioritizing and expediting local repair and follow-up on depot resupply) that would improve their squadrons' readiness.

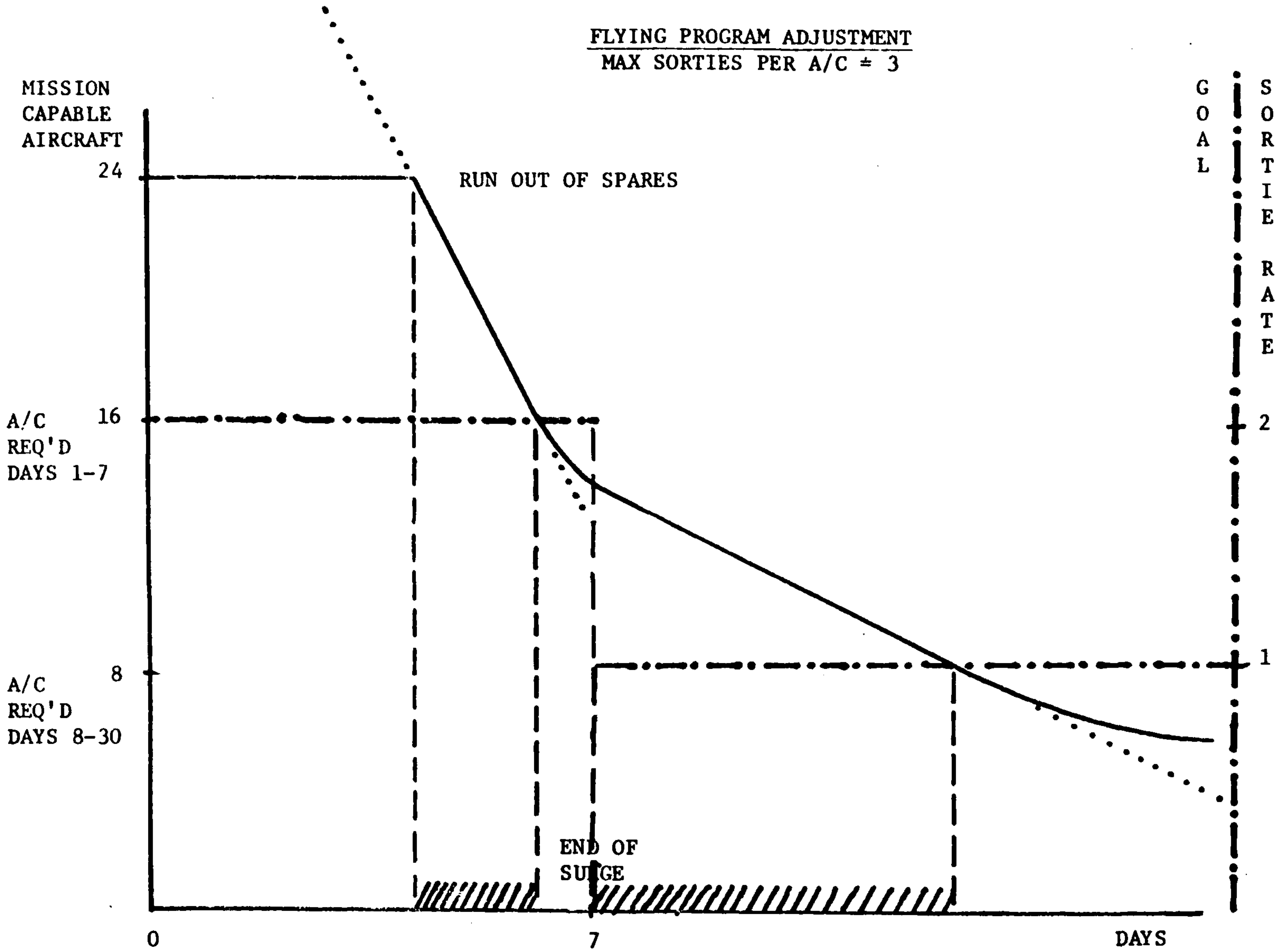


Fig. 7 -- The Need for Flying Program Adjustments

From the above approach to overall NFMC, diagnostic information is also available. By ranking the parts in terms of their sortie or NFMC impacts, one can identify those parts that most constrain performance. In our example, the parts corresponding to figure 4 are most NFMC constraining early on, while those corresponding to figure 5 are constraining towards the end of the 30-day period. Prioritizing and expediting repair/resupply can then be directed according to the period deemed more critical.

3. Automatically Adjusting The Flying Program

Dyna-TAB, an analytic model, adjusts the spare parts consumption so that it corresponds to the expected sorties flown and not necessarily to the sorties initially planned to be flown. In other models of support like Dyna-METRIC, this adjustment is not automatic, but the analyst must adjust the flying demands to make them consistent with the number of flyable aircraft. That requires multiple runs and several manual adjustments of input variables. To avoid this undesirable computational load, Dyna-TAB required an automated adjustment of the flying program.

Figure 7 shows how the consumption of parts (dotted line) of a squadron of 24 aircraft must change its rate (to become the sloping solid line) when, at about day 6, the operational aircraft falls below 16; 16 aircraft are required to fly the goal of 24x2=48 daily sorties when a maximum of 3 sorties per aircraft per day is possible. When the sortie goal drops on day 8, the available aircraft become sufficient in meeting the new sortie goal.

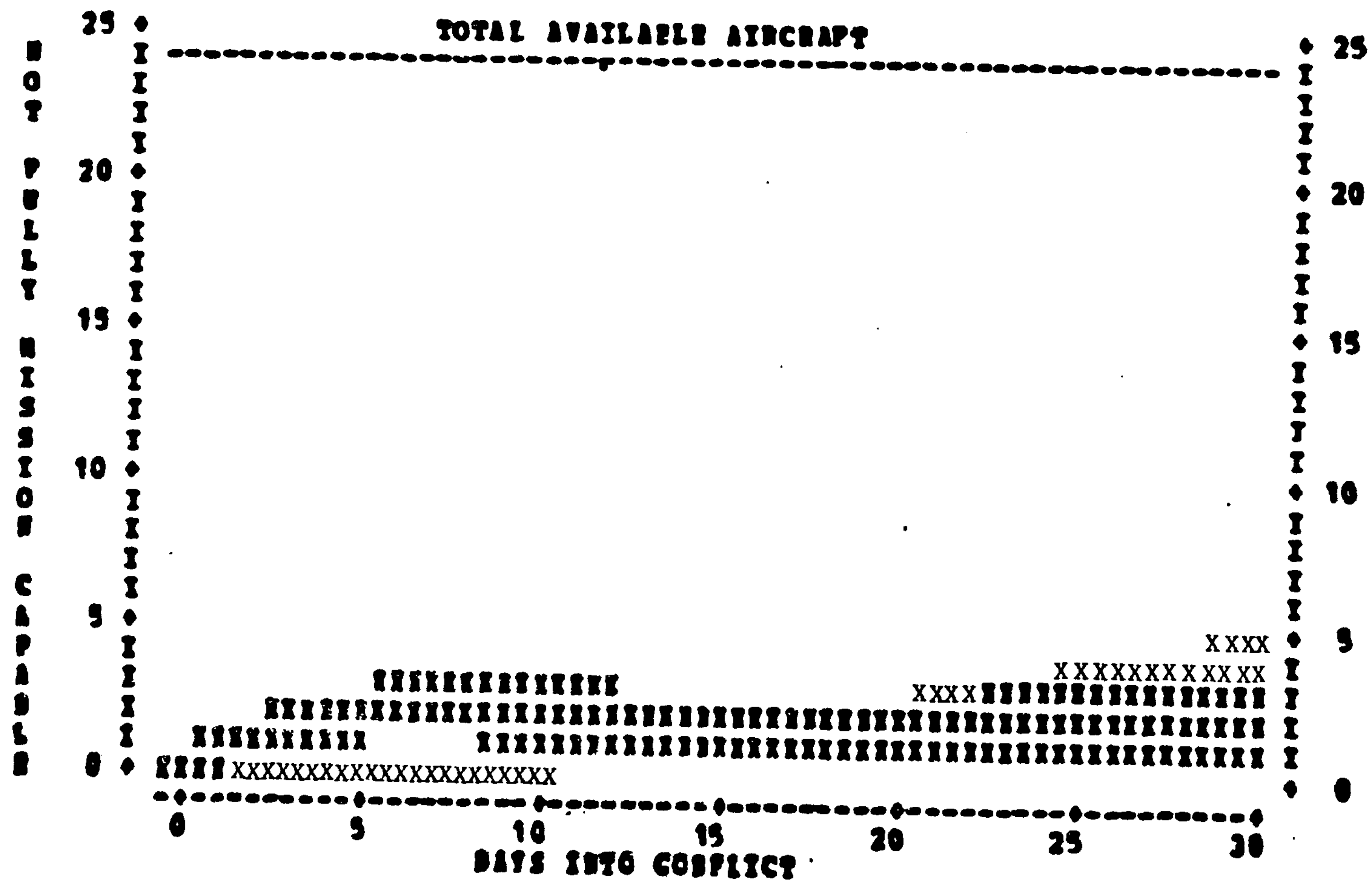


Fig. 6 -- Overlaid Plots Produce NFMC Estimate

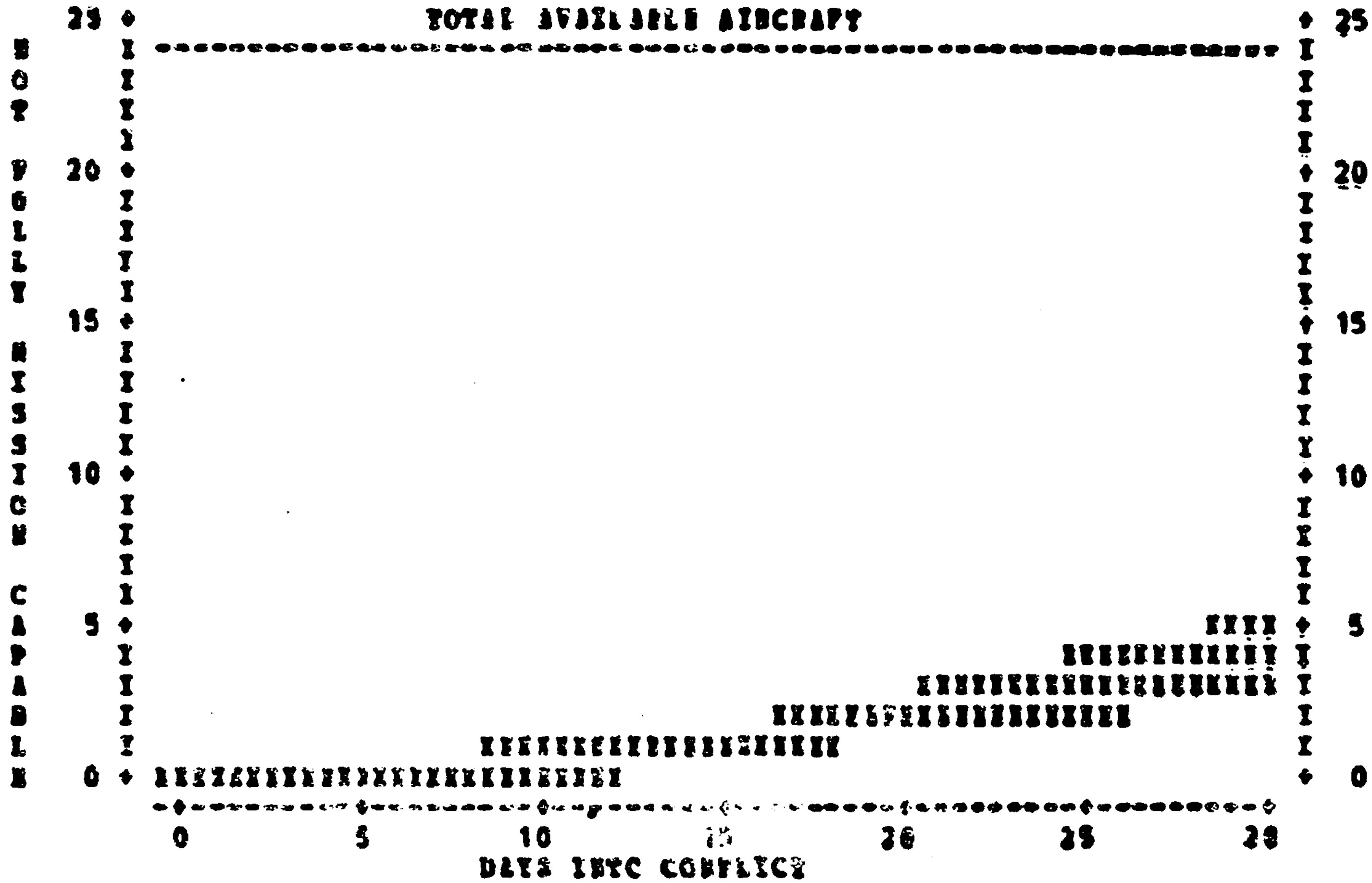


Fig. 5 -- Dyna-[illegible]AB Sample Output: Another NFMC Plot

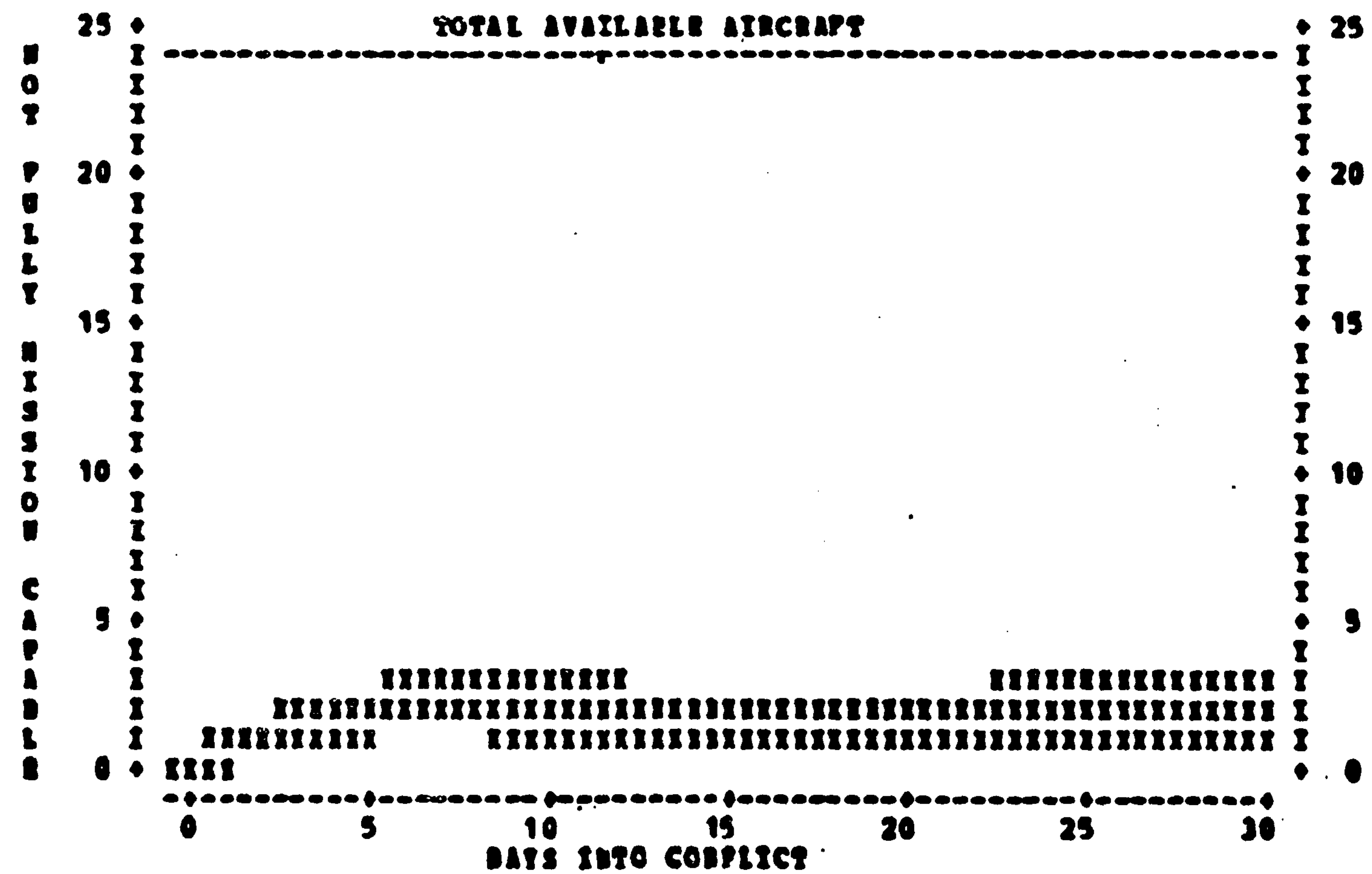


Fig. 4 -- Dyna-TAB Sample Output: An NFMC Plot

2. Assessing the Effect of Worst Parts in Causing NFMC Aircraft

For each of the sortie entries in the table, Dyna-TAB also produces the plot of the Not Fully Mission Capable (NFMC) aircraft over time; thus the NFMC plot in Fig. 4 corresponds to the circled entry in Fig. 3. That plot's lower edge is an estimate of the mean NFMC value. The upper edge shows the 80 percent confidence level for the NFMC, that is, the level below which the NFMC will fall with 80 percent assurance. (In this plot, the early peak is caused by a surge in the flying program, while the increasing NFMC trend later shows the impact of a depot resupply cutoff.) Figure 5 shows another NFMC plot corresponding to another category/stock level mix.

The Squadron Assessment Program of TAC-PACERS automatically overlays the NFMC plots appropriate for the individual categories/stock level mix, resulting in a chart as shown in Fig. 6. The upper edge of Fig. 6 is taken as a slightly conservative estimate of the mean NFMC for the squadron for reasons that we now explain. Under the full cannibalization assumption required by this approach, the NFMC is driven by the most constraining item at each time point. The presence, however, of multiple most constraining items produces a probabilistic compounding effect which inflates the NFMC estimate somewhat. To deal with this value inflation we take the upper edge (80th percentile NFMC) of the overlaid charts to be the estimate of the mean NFMC. This estimate can be shown to be conservative when one or two items are the most constraining in causing NFMC. (The actual number of constraining items is typically small, because WRSK shortages on a given day are likely to occur on few items from which still fewer will turn out to be NFMC constraining).

CASE 3211.1141.

	LRU	SRU
DEM	0.0100	0.0010
NRTS	0.1700	1.0000
OPA	1	1
RCT	6	3

APPLIES TO:	LRU	SRU
	5841010588180	5841001491396
	5841010588180	5841010036768
	5841010588180	5841010074201
	5841010588180	5841010162038
	5841010588180	5841010587295
	5841010588180	5841010587297
	5841010588180	5841010830472
	5865010456276EW	5865010846760EW
	5865010604442EW	5865004775936EW
	5865010731891EW	5865004775605EW
	5865010731891EW	5865004775620EW
	5865010731891EW	5865004775627EW
	5865010731891EW	5865004775908EW
	5865010731891EW	5865004775921EW
	5865010731891EW	5865010369247EW
	5865010731891EW	5865010594991EW
	5865010731891EW	5865010670214EW
	5865010731891EW	5865010674536EW

COMBINED LRU AND SRU EFFECTS ON WARTIME SORTIES:

LRU STOCK = SRU STOCK	0	1	2	3	4	5	6	7	8	9	10
0	1001	1003	1004	1006	1007	1009	1010	1010	1010	1010	1010
1	1001	1003	1004	1006	1007	1009	1010	1010	1010	1010	1010
2	1001	1003	1004	1006	1007	1009	1010	1010	1010	1010	1010
3	1001	1003	1004	1006	1007	1009	1010	1010	1010	1010	1010
4	1001	1003	1004	1006	1007	1009	1010	1010	1010	1010	1010
5	1001	1003	1004	1006	1007	1009	1010	1010	1010	1010	1010
6	1001	1003	1004	1006	1007	1009	1010	1010	1010	1010	1010
7	1001	1003	1004	1006	1007	1009	1010	1010	1010	1010	1010
8	1001	1003	1004	1006	1007	1009	1010	1010	1010	1010	1010
9	1001	1003	1004	1006	1007	1009	1010	1010	1010	1010	1010
10	1001	1003	1004	1006	1007	1009	1010	1010	1010	1010	1010

Fig. 3 -- Dyna-TAB Sample Output: Sortie Table for a Category

range of from zero to one; Dyna-TAB classifies the parts' original NRTS to the closest of these four representative fractions. Similarly, we considered 3 failure rate segments, 2 repair times, and 2 quantities per application. Together with the 4 NRTS they make up 3x2x4x2=48 categories, some of which are discarded because they include no parts.

The concept of categories is also applicable to Line Replaceable Units (LRUs) composed of one or more Shop Replaceable Units (SRUs): they are treated as LRU/SRU part pairs (i.e., each SRU on the same LRU) which are classified into LRU/SRU category pairs.

Dyna-TAB computes the impact of the on-hand level of each LRU (or each LRU/SRU pair) on the resulting NFMC aircraft and sorties, as if it were the only component on the aircraft. Figure 3 shows a sample output of a sortie table for a particular LRU/SRU category; note that the category shown includes many actual part pairs. In the sortie table the circled entry shows the sorties for LRU and SRU on-hand levels of 4. (Note that in this particular example the SRU has little effect on sorties, because the SRU has a relatively small failure rate.) A single Dyna-TAB run provides sufficient information to fill the table, though some entries are obtained by interpolation.

The sortie levels in a table are assigned to each LRU/SRU pair falling in the given category. Using the resulting table and the actual on-hand stock levels for each LRU/SRU pair, base-level managers can estimate how many combat sorties could be flown if only those components were short of authorized levels.

III. ASSUMPTIONS AND CONCEPTS OF DYNA-TAB

The speed requirements needed by TAC-PACERS were met by making certain assumptions and utilizing several approximations. First, the Dyna-TAB design chose a narrower scope than Dyna-METRIC, by excluding modeling of multiple bases, CIRFs, and test equipment queuing. Also Dyna-TAB allows only one change in the surge flying level (as assumed by the standard WRSK computations). Finally, Dyna-TAB computes NFMC aircraft assuming only full cannibalization of parts to maximize the operationally ready aircraft.

Though these assumptions reduced the model's computational demands slightly, the greatest reductions were achieved through the following three new modeling concepts:

1. Classifying parts into categories
2. Assessing the effect of worst parts in causing NFMC aircraft.
3. Automatically adjusting the flying program.

Each concept is discussed in turn.

1. Classifying Parts into Categories

Dyna-TAB takes parts with similar logistics characteristics and groups them into the same category, thus requiring only one pipeline computation for the category instead of one for each part. To create categories, the range of each of the factors was divided into a few segments, each characterized by a representative point. As an example, we considered four not base reparable (NRTS) segments (low, medium, high, maximum) represented by .17, .5, .83, and 1.0 to cover the NRTS

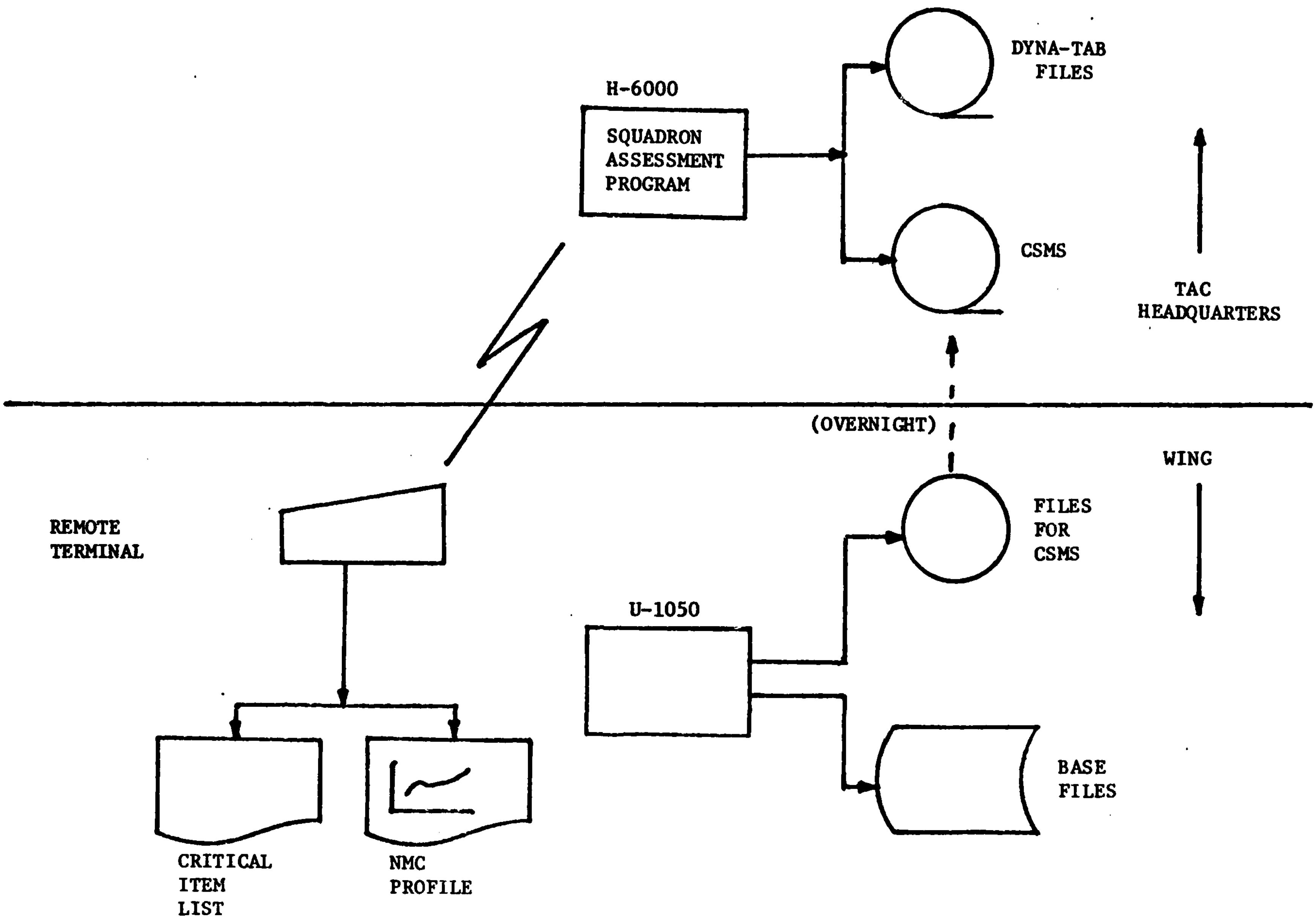


Fig. 2 -- Base Access to PACERS

of sortie tables and NFMC plots in the form of a listing and a file. This machine readable file can be queried by TAC-PACERS in an automated mode; on the other hand, the printout of the plots and tables, though not used by TAC-PACERS, does provide a manual mode querying alternative. Creation of such detailed capability assessment data applicable to all combinations of on-hand stock levels would necessitate numerous Dyna-METRIC runs.* To avoid that heavy computational demand, Dyna-TAB produces the data in one run by taking reasonable computational shortcuts and by making approximations. We'll discuss these shortcuts and approximations in the next section.

Figure 2 depicts the flow of information to and from the Squadron Assessment Program of TAC-PACERS; its runs will be initiated from, and provide results to, a base terminal via a remote communications link. This program uses the on-hand WRSK levels information available to headquarters (brought overnight as part of CSMS) and queries the appropriate entries on the Dyna-TAB files. It then provides an estimate of the squadron's NFMC profile over time as well a list of critical items requiring recovery actions.

---

* Furthermore, there may be the need of additional Dyna-METRIC runs (and human intervention) to adjust the flying program goal when certain parts shortages make it unattainable.

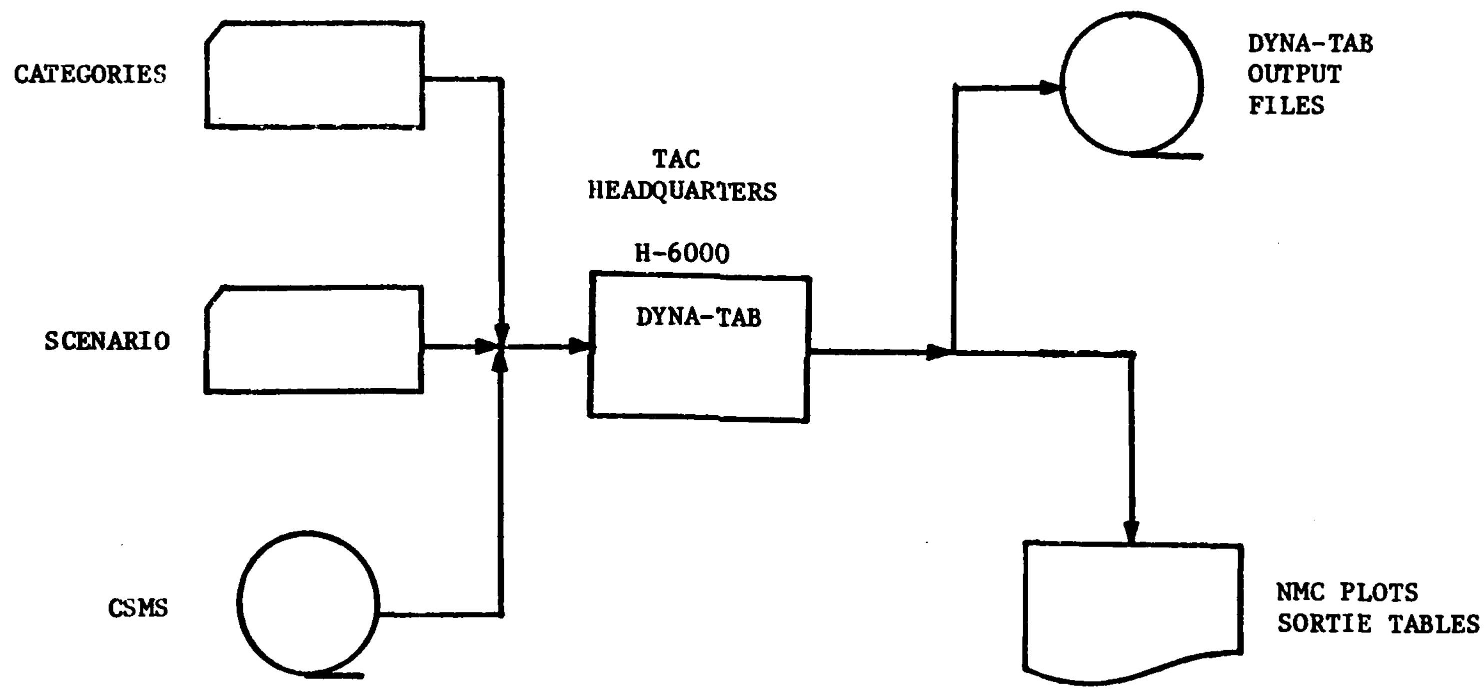


Fig. 1 -- Flow Diagram for Dyna-TAB

II. DESIGN REQUIREMENTS DERIVED FROM TAC-PACERS

TAC-PACERS needs to track the frequent fluctuations of on-hand WRSK levels, therefore its computer runs must be fast enough to avoid creating unacceptable computational requirements. Due to limitations of base computers, TAC-PACERS would have to run at TAC headquarters' Honeywell computer. This computer cannot assess the required 30 or so squadrons by using one of the currently available models such as Dyna-METRIC [2, 3, 4]: the estimated run time of about five minutes for each squadron on a frequent basis creates too big a computational requirement. Still, the Dyna-METRIC type of operational measures, such as sorties and aircraft Not Fully Mission Capable (NFMC), are needed. Therefore, Dyna-TAB was designed to minimize total computational load on the headquarters computer. To accomplish that goal, Dyna-TAB generates a comprehensive set of sortie tables and NFMC plots that base level managers can use to assess their current on-hand WRSK status and its effects on wartime operational capability.* Subsequent assessments need not recompute the sortie or NFMC values; they merely look them up in the table.

Figure 1 shows the input and output flows of Dyna-TAB as it runs on the headquarters computer. Such runs are required only after a change in the logistic factors used in building the WRSK. For input, Dyna-TAB uses the planned scenario and parts logistic factors information (in a Dyna-METRIC format). For output, Dyna-TAB creates the comprehensive set

* Both automated and manual tables and plots are produced. The remaining computational task is so slight that a user can use the model's reports manually by merely looking up each short component's effects in the tables.

The next section will describe Dyna-TABS's design requirements as derived from the goals of TAC-PACERS, while the final section will describe the assumptions and concepts used in Dyna-TAB in meeting the design goals.

Validation

We saw in the previous sections how the size and speed requirement on Dyna-TAB were met by the use of shortcuts and approximations. To monitor their combined effect, comparison runs of Dyna-TAB against Dyna-METRIC were made both at TAC and RAND; their results have shown close agreement, thus paving the way for Dyna-TAB to be embedded in TAC-PACERS.

REFERENCES

1. Clarke, Lieutenant Colonel Ronald, Real Time Unit Level WRSK Capability Assessment System paper submitted to the LOGCAS '82 Conference, March 1982.

2. Hillestad, R. J., and M. J. Carrillo, Models and Techniques for Recoverable Item Stockage when Demand and Repair are Nonstationary, Part 1: Performance Measurement, The Rand Corporation, N-1482-AF, 1980.

3. Hillestad, R. J., Dyna-METRIC: A Mathematical Model for Capability Assessment and Supply Requirements when Demand, Repair and Resupply are Nonstationary, The Rand Corporation, R-2785-AF, 1982.

4. Pyles, R., The Dyna-METRIC Readiness Assessment Model: Motivation, Capabilities and Uses, The Rand Corporation, R-2886-AF (forthcoming).

TITLE: TLR/S - An Army Methodology for Assessing Logistics Readiness and Sustainability

PAPER PREPARED BY: Mr. James A. Cohick

ORGANIZATION: The US Army Logistics Evaluation Agency (USALEA)

LOCATION: New Cumberland Army Depot, New Cumberland, Pennsylvania 17070

ABSTRACT: A continuing need has existed for Army logisticians to assess and articulate the effect on primary weapon system combat readiness and battle sustainability resulting from shortages in support equipment and degraded capabilities of combat service support units.

This need is part of an overall effort in the Army to "balance the forces" to assure that a proper mix of combat to combat support units is maintained so that "for want of a nail" the battle is not lost.

The USALEA Total Logistics Readiness and Sustainability (TLR/S) assessment is an important contribution to this effort. It uses output from many other Army sources to arrive at an assessment of the impact of logistics capabilities on the major combat functions of "shoot, move, and communicate." It breaks this assessment down by combat arms branch (i.e., infantry, armor, artillery, etc.) so that it is meaningful to the major Army commanders and combat arms planners who will be most affected by the results.

This paper describes, in a general and unclassified way, the following:

- USALEA mission and functions; location within the Army structure.
- What is involved in USALEA Readiness/Sustainability Assessment.
- Methodology used in the assessment.
- Example of results of assessment.

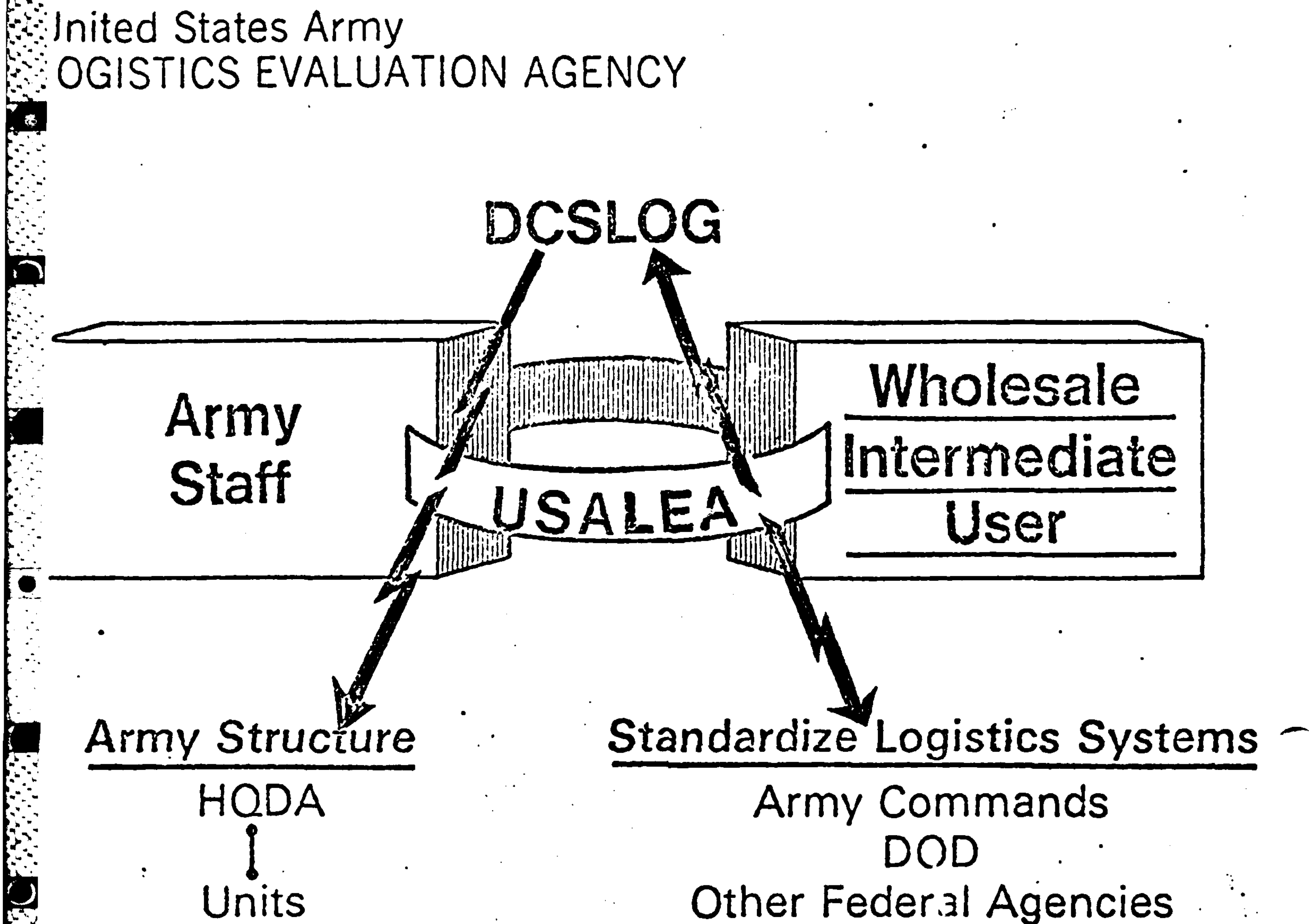


CHART 1

USALEA is a field operating agency reporting to the HQDA Deputy Chief of Staff for Logistics (DCSLOG). The primary mission of USALEA is to execute HQDA DCSLOG policies. Associated missions include—

a. Assess the Total Logistics Readiness and Sustainability of the Army.

b. Evaluate the logistics aspects of the contingency plans and force structures.

c. Serve as the independent logistician in the materiel acquisition process.

d. Provide technical guidance, procedures, and assistance to the Army in the field in the execution of policy, directives, and guidance issued by the HQDA DCSLOG.

Chart 1 illustrates the interrelationships USALEA has with HQDA elements, major Army commands, Defense agencies, and other Federal organizations, across national, wholesale, and retail levels of management and operations.

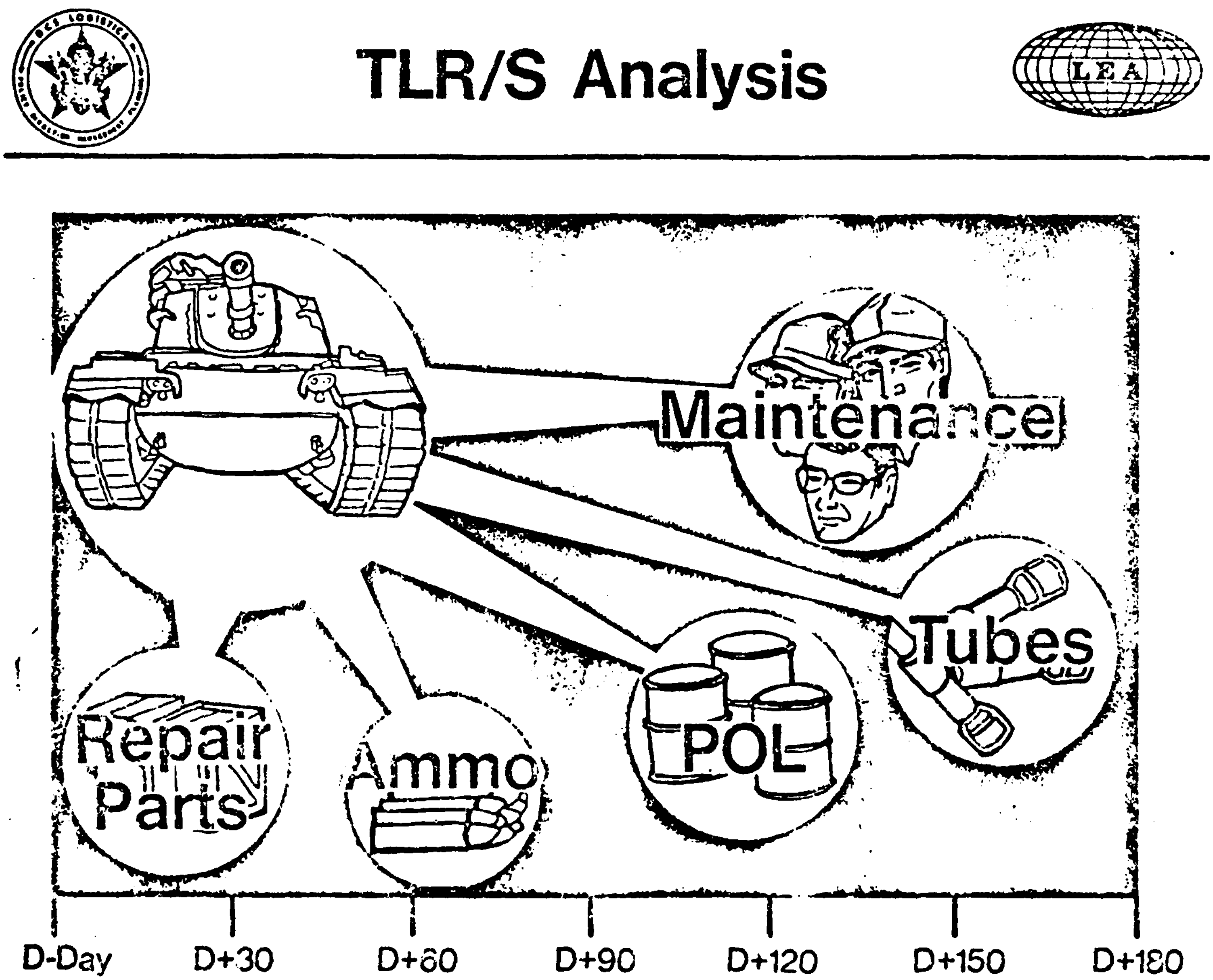


CHART 2

The Total Logistics Readiness and Sustainability analysis is a comprehensive assessment of the capability of the US Army to deploy logistically ready forces and to sustain them in combat, consistent with current, approved scenarios. The essential element of analysis is this--at a point in time, can we field and support combat forces at a specific location over so many days of fighting to perform their functions of "shoot, move, and communication"?

Chart 2 illustrated some of the logistics support requirements to sustain a tank in a combat situation.

TLR/S

WHAT ? - AR 700-5, Total Logistics Readiness/ Sustainability

WHY ? - Assess logistical capability to deploy ready force/sustain force in combat

- Cornerstone for the DCSLOG's Annual Logistics Assessment (ALA)

WHO ? - Army logistical community

WHEN ? - OMNIBUS - in conjunction with CAA

CHART 3

What is it? Total Logistics Readiness/Sustainability is defined in AR 700-5 as an analysis process developed to assess the capability of the Army logistics system (and its subsystems) to sustain forces engaged in combat at a point in time consistent with specific scenarios.

Why do TLR/S? First - the Army (and our Agency in particular) is directed by AR 700-5 to complete the assessment. Second - it provides detailed information on materiel, personnel, and unit availability/nonavailability to

facilitate wartime planning and assist in the prioritization of procurement requirements.

Who is involved in TLR/S? The entire Army logistics community to the extent required.

When is TLR/S analysis completed? Annually, in conjunction with the Army Operational Readiness Analysis (OMNIBUS), that is completed by the US Army Concepts Analysis Agency (CAA).

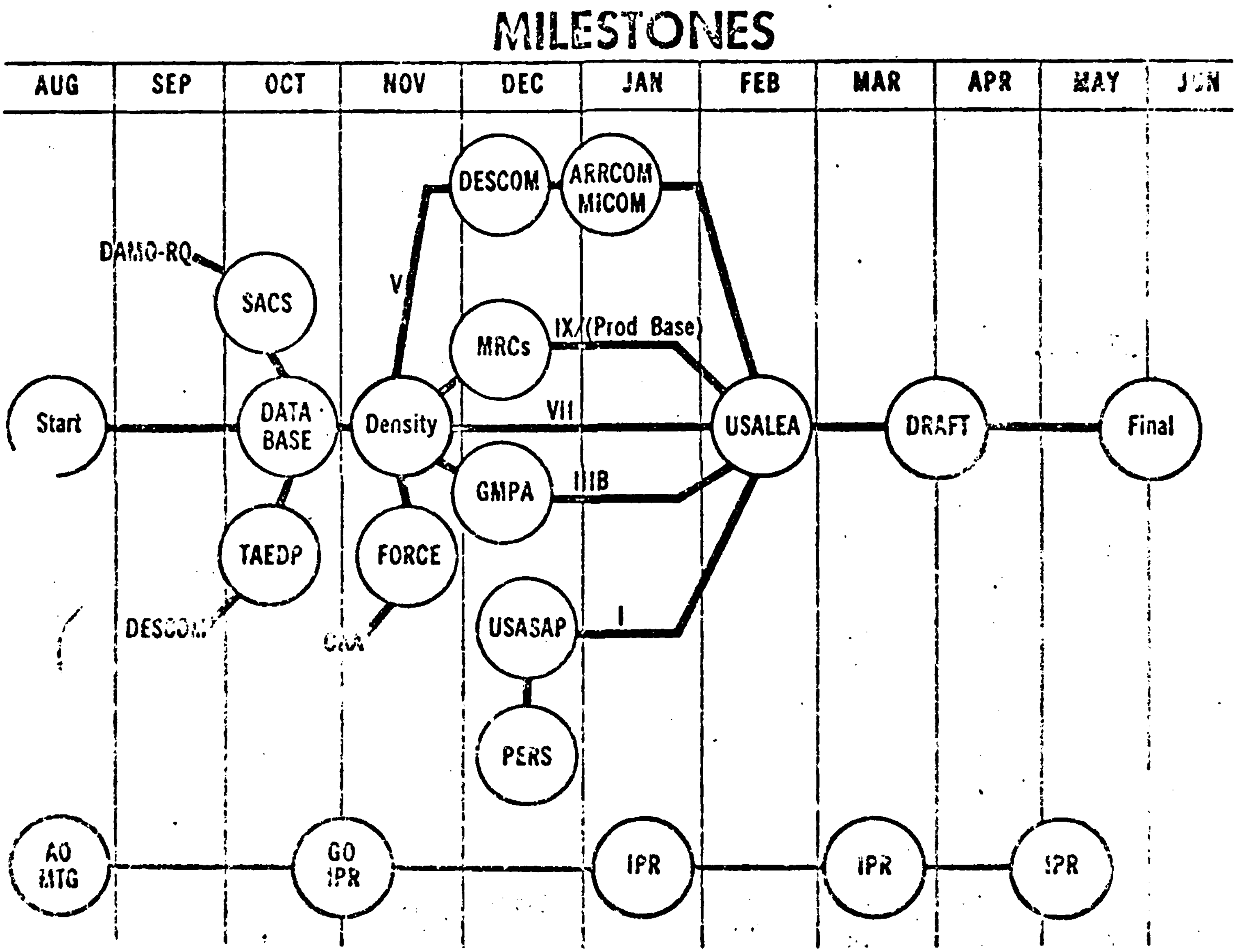


CHART 4

Chart 4 shows the milestones and activities involved in TLR/S for computation of materiel requirements. The process starts with the receipt of a force from CAA with availability dates in the forward edge of the battle area. This time-phased force is matched with the corresponding asset file to generate the daily required on-hand quantities in the force for the major end items being analyzed. Loss rates are applied on a daily basis. Current assets in the supply system are applied daily to the difference between the required and on-hand quantity based on availability. We produce a daily required weapons density profile for the ammunition analysis. These data are provided to DESCOM (Depot Systems Command) where ammunition consumption rates are applied on a daily basis. The resultant requirements are then provided to ARRCOM (Armament Materiel Readiness Command) and MICOM (Missile Command). Their available assets and projected receipts from production are applied to the requirements. For repair parts, the Class VII densities generated in the first step are provided to the appropriate DARCOM materiel readiness commands (MRCs). These commands compute combat essential repair parts requirements by applying the maintenance factor for each combat essential NSN to the on-hand quantity and then factoring this requirement with a combat intensity rate to arrive at a wartime Class IX requirement. All available wholesale and theater assets plus assets due in from either maintenance or production are used; this includes DLA assets obtained through a data interchange between DARCOM and DLA. For bulk POL requirements, we compute the daily density of all fuel burners in the force at the line item number (LIN) level and provide this data to the General Materiel and Petroleum Activity (GMPA) in New Cumberland. GMPA applies the fuel consumption rates to generate requirements. They then apply the available war reserve assets provided by the Army Energy Office and compute the sustainability in days-of-supply by POL product and by piece of equipment. For computation of rations or Class I, the personnel strengths, after casualties are assessed and replacements are received, are determined. The figures for all the Services and allies are aggregated. These personnel strengths are provided to the US Army Support Activity, Philadelphia (USASAP), which computes the requirements for rations and applies all Service-owned as well as DLA-owned assets to the requirement. The results of these processes are provided to our Agency for further analysis.

TLR/S EQUIPMENT/UNIT SELECTION CRITERIA

Level ∫	Combat Unit	Direct Support	General Support
Shoot	X		
Move	X		
Commo	X		
Rearm	X	X	X
Refuel	X	X	X
Recover	X	X	X
Repair	X	X	X
Resupply	X	X	X

CHART 5

Chart 5 shows the functions used to select candidates for analysis. The combat and sustainability functions performed are identified along the left and the level within the theater where they are performed is across the top. The combat functions are always performed in a combat or combat support unit such as Infantry, Mechanized Infantry, Armor, Air Defense, Cavalry, Field Artillery, etc. These units also have a limited capability to perform the sustainability functions. However, sustainability within a given theater is found primarily in the direct support and general support units in the division support command, the corps support command, and in the communications zone.

COMBAT UNIT EQUIPMENT/FUNCTIONS
(FA BN, 155mm (SP)/TARGET ACQ BTRY, MECH DIV)

Equipment	S	M	C	REA	REF	REC	REP	RES
Howitzer, 155mm, SP	XXX	XXX	XXX					
FDC Computer, M18	XX							
Radar, Mortar LOC, AN/TPQ-36	XX							
FM Radios, AN/VRC-46,-47,-49			XXX					
Carrier Cargo, FT, M548	XX			X				
Truck, Cargo 8T	XX			X				
Truck, Tank Fuel SVC, 2500 Gal		XX			X			
Recovery Veh, LT M578		XX				X	XX	

XXX Combat Function Performed
XX Function Supported
X Sustaining Function Performed

CHART 6

Chart 6 gives a sample of the type of equipment and its function in a combat unit. Support equipment, in addition to supporting a combat function, can also perform other functions and requires support itself. For example, the M548 supports the "shoot" function by providing the artillery battalion the capability to rearm itself. It also moves and requires refueling, recovery, repair, and resupply. Target acquisition and fire control equipment is included in the shoot function.

SUPPORT UNIT EQUIPMENT/FUNCTIONS
(CONV AMMO CO (DS/GS) / MAINT BN (MECH DIV)

Equipment	S	M	C	REA	REF	REC	REP	RES
Crane Whl Mtd, 5T, DSL	XX			X				
Crane, Whl Mtd, 20T, DSL	XX			X				
Trk, Forklift DSL, 6000#	XX			X				
Trk, Forklift DSL, 10000#	XX			X				
Shop Eqpt/FC Syst Repair	XX						X	
Shop Eqpt, Arty	XX						X	
Trk, Tractor, HET, 85000#		XX				X		
Shop Eqpt/Contact Maint Trk Mtd		XX					X	
ectronic Shop, Shelter Mtd			XX				X	

XX Combat Function Supported
X Sustaining Function Performed

CHART 7

Chart 7 is an example of equipment in combat service support units. The equipment supports but does not perform combat functions. Also, the equipment requires support from other sustainability functions. Note that while the conventional ammunition company supports the shoot function exclusively, the divisional maintenance battalion supports all of the combat functions.

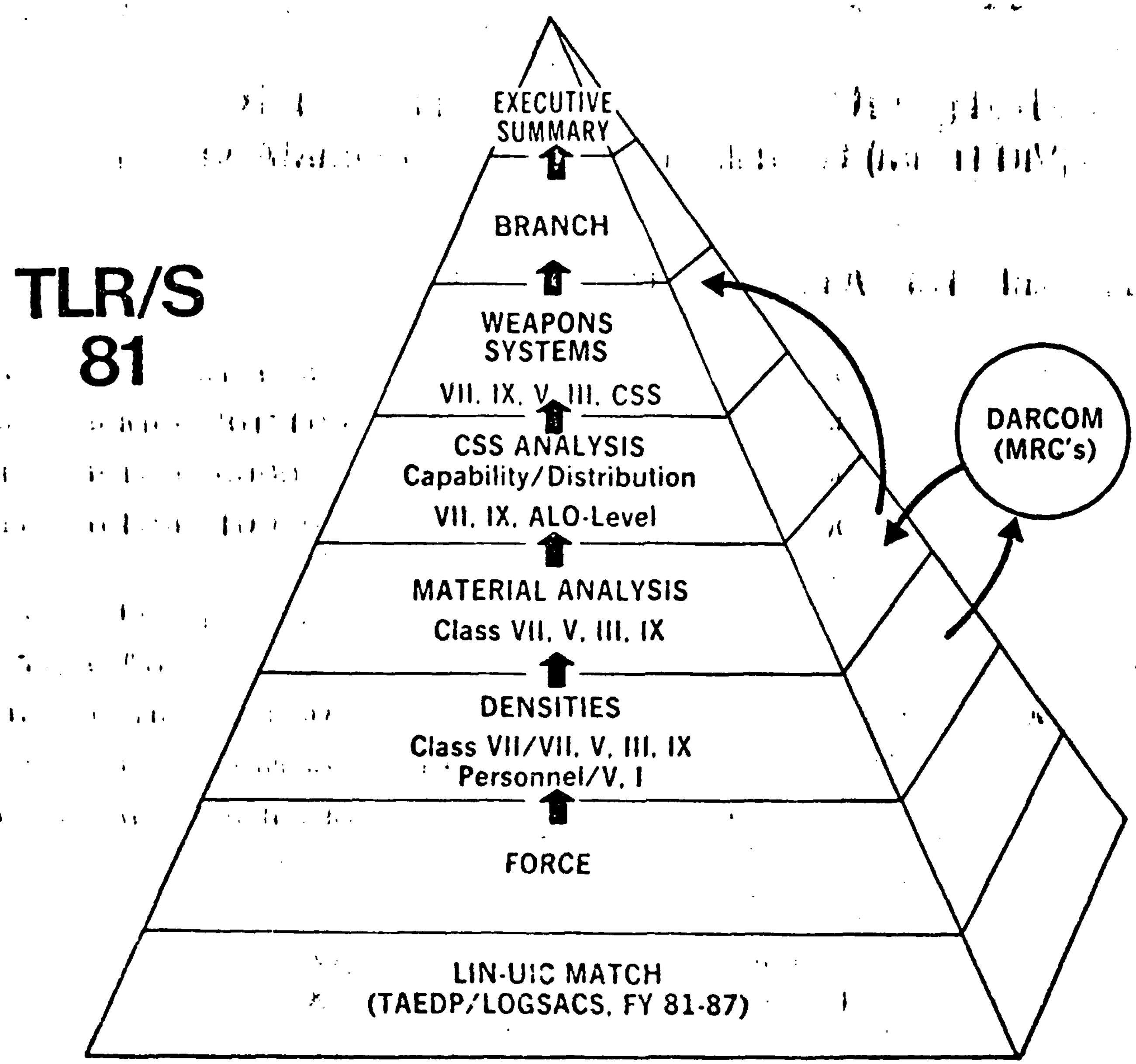


CHART 8

Chart 8 provides a review of the TLR/S process from a different approach. The effort begins with the identification of the major weapon systems to be analyzed (the third layer down on the pyramid). This is done in coordination with Army operations planners (ODCSOPS, CAA), as well as Army logistics organizations (ODCSLOG, DARCOM, USALEA).

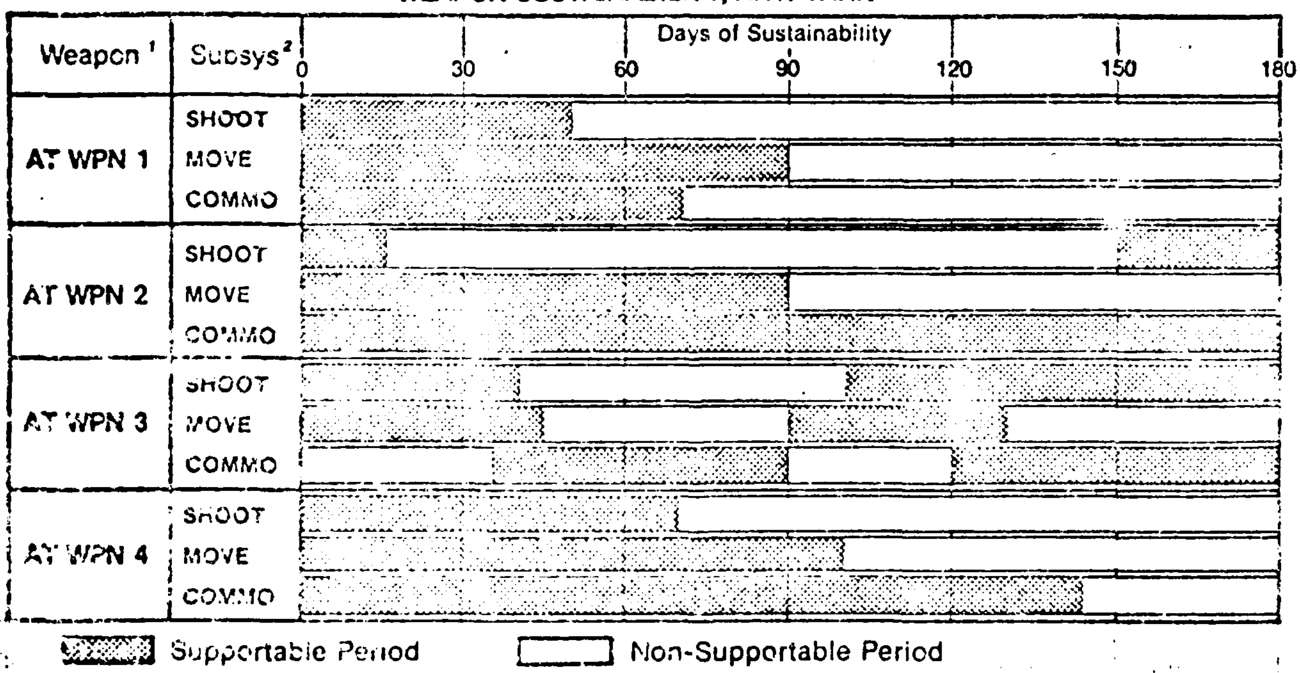
Then, beginning at the bottom of the pyramid and moving upward: LIN-UIC match - We match the weapon systems line item numbers (LIN) to the actual Army units

(UIC-unit identification codes) authorized the systems to determine the overall weapon system asset posture.

The next step is to apply this asset posture to the Army current force (after OMNIBUS analysis) which generates weapon systems and support materiel densities over time. The densities are sent to the appropriate DARCOM materiel readiness commands for their review and analysis and input to the TLR/S analysis. We at USALEA use that input along with our own end item data to accomplish the materiel analysis. The workload generated by the materiel assessment establishes a base from which a combat service support (CSS) capability/distribution system analysis can be performed. The CSS and materiel analyses are integrated at the weapons systems level to arrive at a readiness posture for the "shoot, move, and communication" subsystems.

Finally, the weapon systems are aggregated at the branch (e.g., Infantry, Armored, Air Defense) level for display purposes, and preparation of a report, including an executive summary.

WEAPON SUSTAINABILITY, ANTI-TANK



[1] Fictional weapons used to avoid data classification.

[2] Specific limiting factors, such as particular ammunition rounds, are identified separately in the report.

CHART 9

Chart 9 shows a sample of TLR/S materiel analysis using fictional weapons and imaginative information for supporting equipments/materiels.

The purpose of the information displayed in Chart 9 is to support the computation of types and quantities of materiel to be acquired and maintained on hand for contingencies. The end result is to balance resources to the extent possible. The TLR/S assessment involves an extremely large volume of detailed information. That is first of all gathered annually, then refined and summarized, and lastly displayed in easily interpreted color coded graphs.

THE IMPACT ON COMBAT CAPABILITY OF RECOVERABLES AWAITING PARTS

A W P

THE #1 SPARES PROBLEM

(WILLIAM D. ARNOLD)

LG 3937

AWAITING PARTS

AWAITING PARTS (AWP) IS:

- AN INTERRUPTION OF THE BASE OR DEPOT REPAIR CYCLE WHERE ALL RESOURCES REQUIRED TO EFFECT THE REPAIR OF A RECOVERABLE ITEM ARE AVAILABLE <u>EXCEPT</u> PARTS
  - PARTS REQUIRED CAN BE:
    - EXPENDABLE (XB3 OR XF3) "BITS AND PIECES"
    - RECOVERABLE (XD2) "SRU'S"
  - PARTS REQUIRED COME FROM:
    - AFLC
    - DLA
    - OTHER

    $\left.\begin{array}{l}\text{AFLC}\\\text{DLA}\\\text{OTHER}\end{array}\right\}$ EXPENDABLES AND RECOVERABLES

LG 3938

AWAITING PARTS

THE IMPACT OF THE TOTAL PARTS PROBLEM ON TAC:

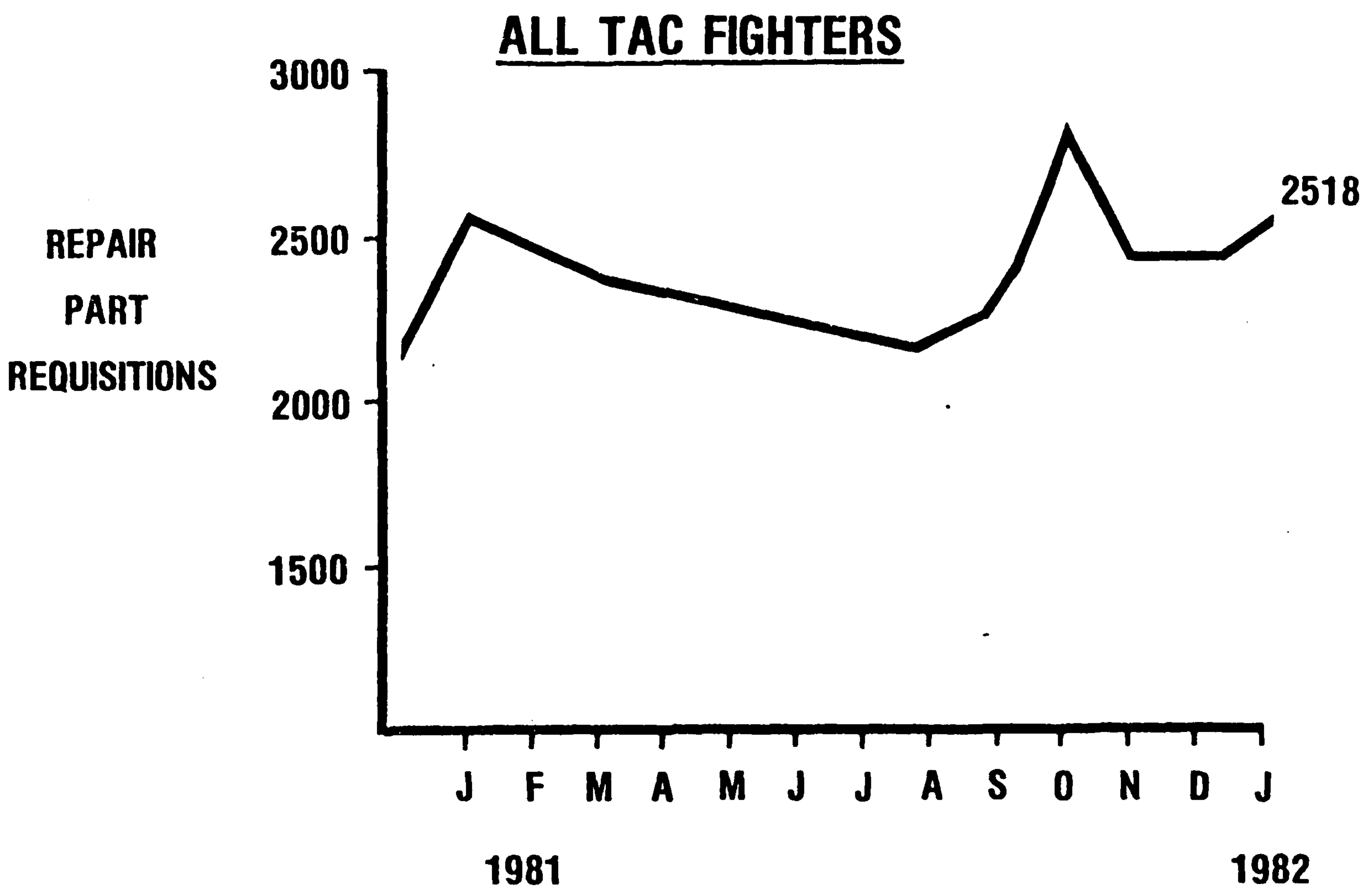
- 60 + FIGHTERS ARE HANGAR QUEENS
  - HAVE NOT FLOWN FOR $\geq$ 21 DAYS
    - FOR A LACK OF PARTS
- 10 FIGHTER SQUADRONS ARE TNMCS
  - 15% OF TOTAL FORCE
  - 4,200 SORTIES IN FIRST 7 DAYS OF WAR

THE AWP IMPACT

- 2 FIGHTER SQUADRONS TNMCS FOR AWP RECOVERABLES
  - 840 SORTIES IN FIRST 7 DAYS OF WAR
- 1880 NMCS INCIDENTS IN JAN 82
  - FULL BASE STOCK ON HAND - REQUIRED QUANTITY AWAITING PARTS

LG 3939

HOW BIG IS IT?



LG 3942

REPEAT PROBLEM ITEMS

AUG 81 vs. JAN 82
(REPAIR PART)

AWP QTY AUG 81	0	1	2	3	4	5	6	7	8	9+	
9+	7	3	2							10	
8	2	1									
7	1										19
6	6	1	1								
5	11	4									
4	13	4	3								40
3	26	7									
2	121	16	13	10	6	4	2	1	2	3	
1	820	55	18	14	3	4	4		3	1	2,208
0		770	138	41	25	18	6	7	1	10	

AWP QTY JAN 82

LG 3945

NOTE: MOST OF THE REPAIR PART REQUIREMENTS APPEAR TO BE TRANSITORY. FEW ITEMS (STOCK NUMBERS) HAD HIGH QUANTITIES ON ORDER IN AUG 81 AND WERE STILL HIGH IN JAN 82.

REPEAT PROBLEM ITEMS

AUG 81 vs. JAN 82
(END ITEM)

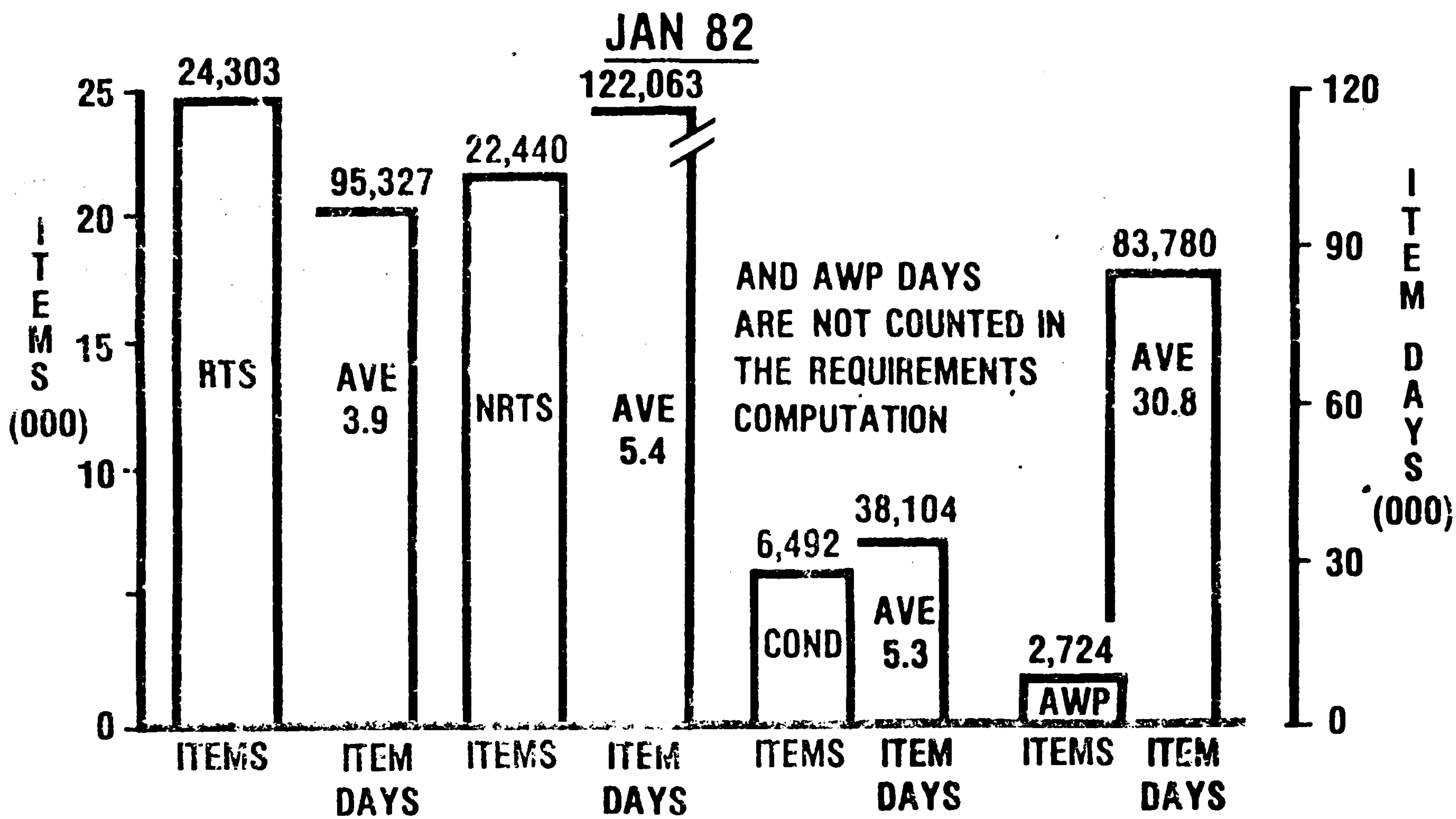
AWP QTY AUG 81	0	1	2	3	4	5	6	7	8	9+	
9+	1		1	1	1	1	1	3	3	18	33
8	3	1		1					1		
7		1	4					1	2		
6	1	1		1			1	1		2	
5	1	2	3	3	2			2			
4	6	5	2	4	2	6	1				39
3	12	18	8	3	2	4		3		2	
2	57	32	12	10	2	4	2	6	2		
1	222	71	23	9	8	3		4		6	832
0		227	35	12	9	3	1	1	1		

AWP QTY JAN 82

NOTE: MANY OF THE END ITEMS AWAITING PARTS (AWP), APPEAR TO BE TRANSITORY. THERE ARE A SMALL NUMBER OF ITEMS THAT ARE CONSISTENTLY AWP.

LG 3944

THE TAC BASE REPAIR CYCLE



NOTE: WHILE A SMALL NUMBER OF ITEMS ARE AWAITING PARTS, THEY REPRESENT A SUBSTANTIAL PIPELINE. IN FACT, WE CAN SEE THE AWP PIPELINE (83,780 ITEM DAYS) IS ALMOST AS LARGE AS THE BASE REPAIR CYCLE PIPELINE (95,327 ITEM DAYS).

SOURCE: 19 BASES' M-32

LG 3974

AFLC CRITICAL ITEMS

- CRITICAL SPARE PARTS - ACCUMULATED 1,000 HOURS OR MORE USER WAIT TIME DURING A MONTH FOR A MISSION LIMITING SPARE
- THE MOST FREQUENTLY CITED CAUSE FOR THE LACK OF SPARES FOR TACTICAL AIRCRAFT:
  - COMPONENT PARTS SHORTAGE FOR REPAIR OF THE SPARE

—AWP—

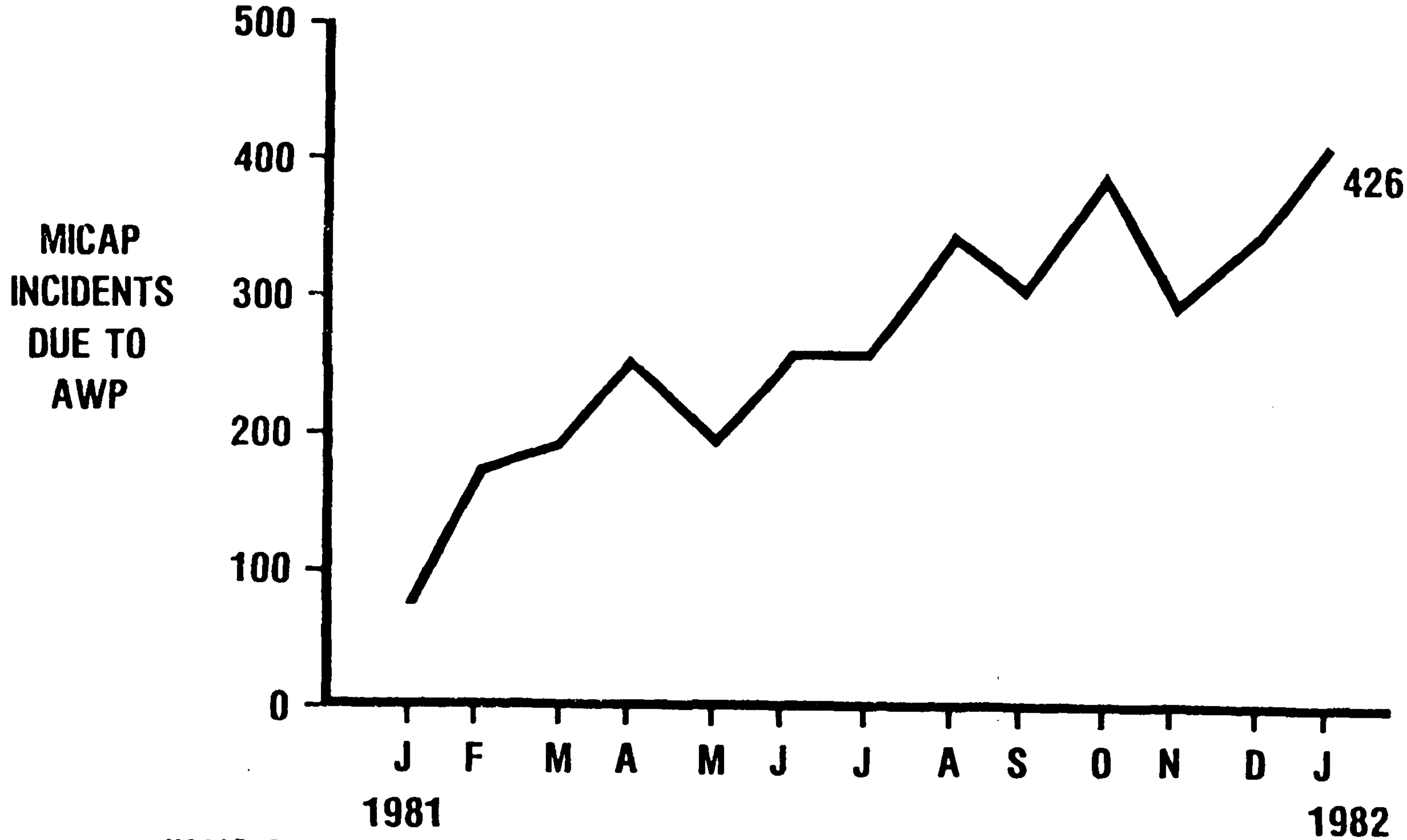
LG 4246

AFLC INITIATIVE

- LO DIRECTED ALC REVIEW OF AWP - AUG 81
  - ALC REPLIES
    - AWP VERY REAL PROBLEM - BASE AND DEPOT
    - LARGE, SEVERE, VERY COMPLEX
    - CONTINUE EFFORTS TO SOLVE

LG 4247

F-15 EXPERIENCE



LG 3953 MICAP INCIDENT: FAILURE OF THE INVENTORY SYSTEM. PEACETIME OPERATING STOCK INVENTORY COULDN'T SUPPORT A NEED FOR A MISSION LIMITING SPARE.

HARD CORE BAD ACTOR

		AWP ON ORDER			
		OCT 80	AUG 81	DEC 81	PAST YEAR MICAP INCIDENTS
END ITEM:	ANTENNA	33	29	18	627
	GIMBAL		3	6	135
REPAIR PARTS:	ARRAY ASSY	5	13	3	132
	CABLE ASSY	5	9	7	64
	GYRO		1	9	20
REPAIR PART REPAIR PART:					978
	ELEVATION CABLE	DEPOT LEVEL REPLACEMENT ONLY			
	TORQUE MOTOR				
	TACHOMETER				

MDS: F-15

SYSTEM: RADAR

MANAGED BY: WARNER-ROBINS

NOTE: WHILE THESE ITEMS ARE MANAGED INDIVIDUALLY, THEY ARE ALL RELATED AND TOGETHER THEY ACCOUNT FOR ALMOST 1000 MICAP INCIDENTS. THE TORQUE MOTOR AND TACHOMETER ARE THEMSELVES REPARABLE AND REQUIRE A FURTHER INDENTURED LEVEL OF PARTS.

LG 3954

REPAIR . ARTS CAUSE CODE ANALYSIS

WHY WEREN'T THE REPAIR PARTS IN BASE STOCKS?

PERCENT OF UNFILLED DEMANDS

		NO STOCK LEVEL	LEVEL BUT NO STOCK	OTHER	TOTAL
SOURCE OF SUPPLY	SMALC	9	[redacted]	0	18
	OOALC	25	[redacted]	0	15
	OCALC	26	[redacted]	1	8
	WRALC	22	[redacted]	0	37
	SAALC	39	59	2	5
	DLA	59	41	0	15
	OTHER	73	27	0	2
	TOTAL	28	72	0	100

LG 3960

FACTORS INFLUENCING SORTIES

EXPERIMENTAL RESULTS - CONT.

MULTIPLE REGRESSION ANALYSIS

$X \equiv$ TURN RATE $\quad Y \equiv$ DAY

$Z \equiv$ EXPECTED AVAILABLE AIRCRAFT $\quad ES(t)$ = EXPECTED SORTIES

C. B. DELAY 0.2 DAYS

$$ES(t) = 16.589 + 1.673X - 0.093Y \quad (R^2 = .657)$$

$$ES(t) = -19.226 + 12.584X - 0.856X^2 + 2.826Z - 0.516XZ \quad (R^2 = .947)$$

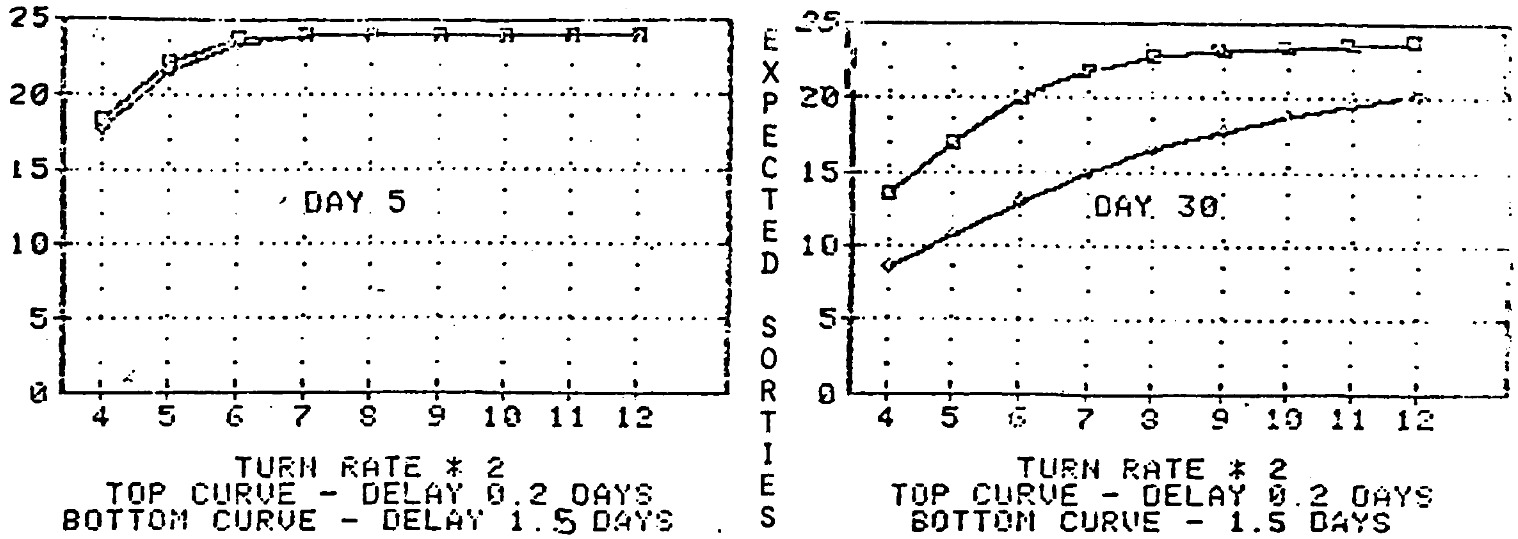
C B. DELAY 1.5 DAYS

$$ES(t) = 13.421 + 2.090X - 0.109Y \quad (R^2 = .490)$$

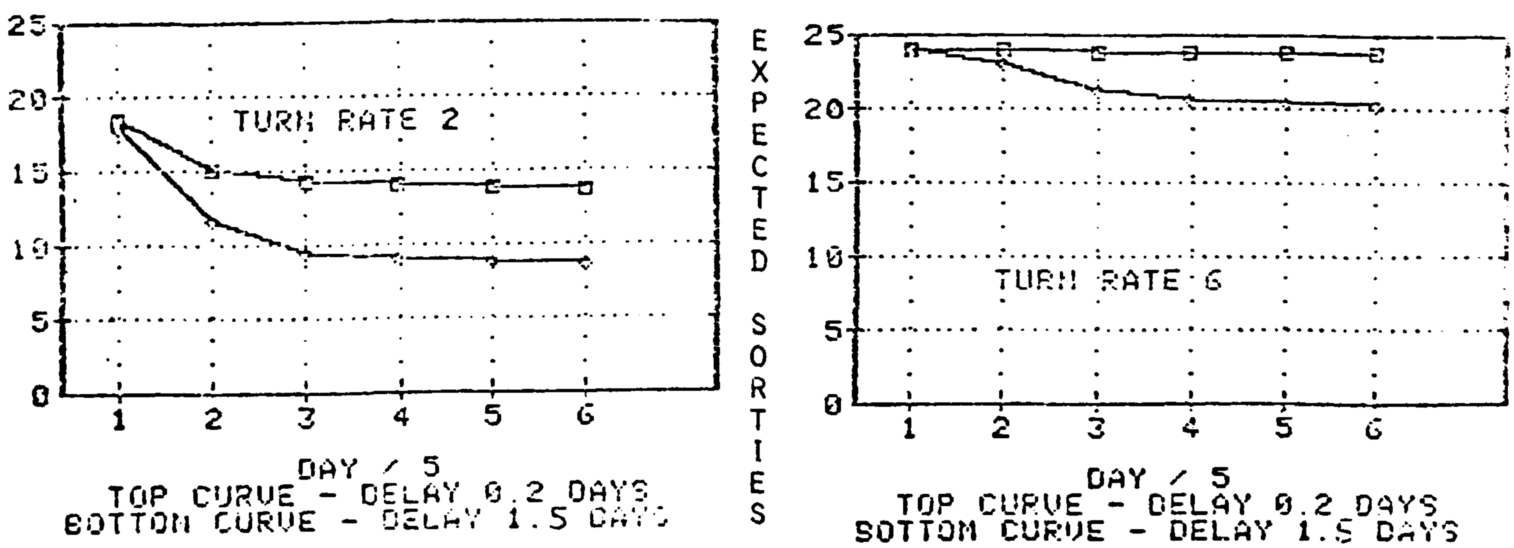
$$ES(t) = - 13.367 + 10.534X - 0.792X^2 + 2.220Z - 0.337XZ \quad (R^2 = .777)$$

FACTORS INFLUENCING SORTIES

EXPERIMENTAL RESULTS



EXPECTED SORTIES FLOWN BY TURN RATE



EXPECTED SORTIES FLOWN BY DAY

FACTORS INFLUENCING SORTIES

DESCRIPTION OF EXPERIMENT

- IMPLEMENTATION OF ANALYTICS CHECKED
- FACTORIAL EXPERIMENT CONDUCTED
  - SORTIE RATE = 2.0
  - FH/SRT = 2.0
  - TURN RATE = 2 TO 6 IN STEPS OF 0.5
- MULTIPLE REGRESSION PERFORMED
  - EXPECTED SORTIES BY TURN RATE AND DAY
  - EXPECTED SORTIES BY TURN RATE AND EXPECTED AVAILABLE AIRCRAFT

FACTORS INFLUENCING NMCS

EXPERIMENTAL RESULTS - CONT.

MULTIPLE REGRESSION ANALYSIS

$X \equiv$ DEMANDED FLYING HOURS $Y \equiv$ DAY OF WARTIME PERIOD

$E\ Nc\ (t) \equiv$ EXPECTED FULL CANNIBALIZATION NMCS

<u>C. B. DELAY 0.2 DAYS</u>

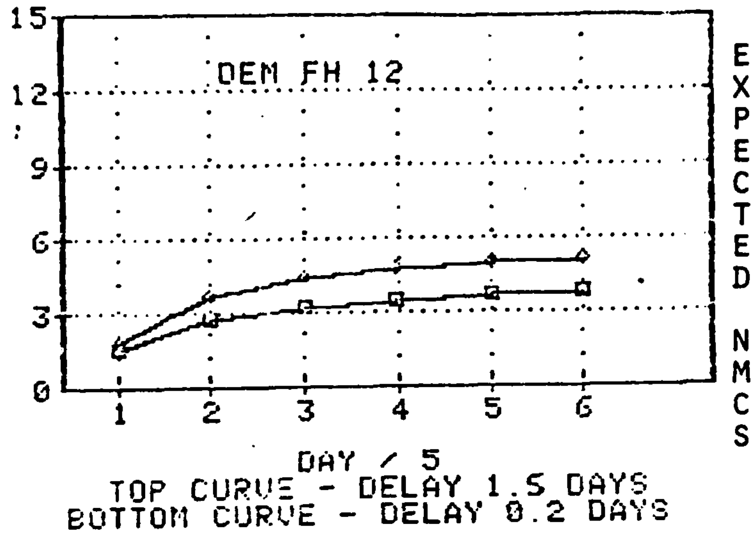
$$E\ Nc\ (t) = -3.622 + 0.72X + 0.547Y - 0.12Y^2 \quad (R^2 = .904)$$

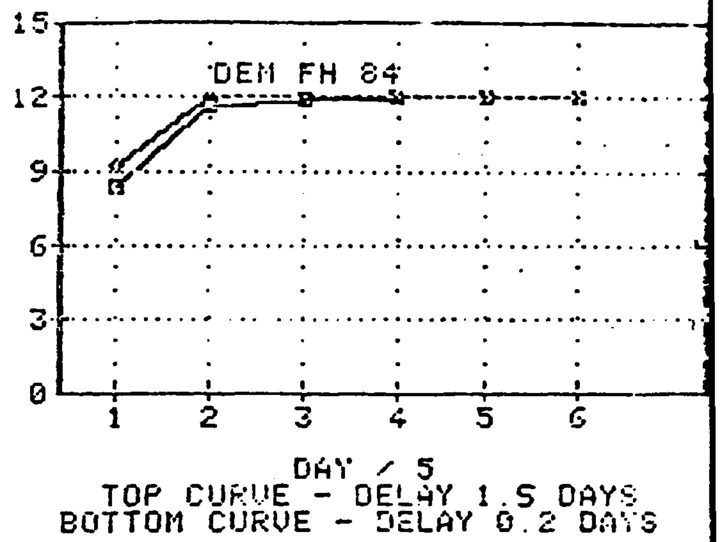
<u>C. B. DELAY 1.5 DAYS</u>

$$E\ Nc\ (t) = -4.506 + 0.78X + 0.804Y - 0.18Y^2 \quad (R^2 = .889)$$

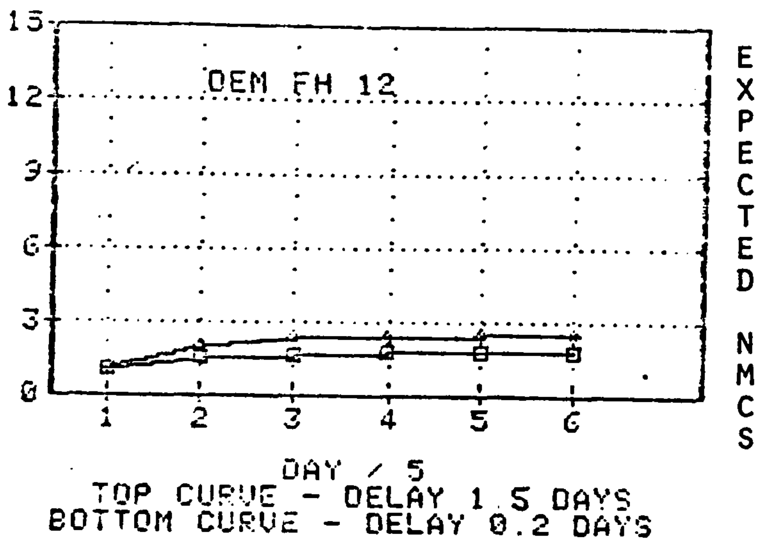
FACTORS INFLUENCING NMCS

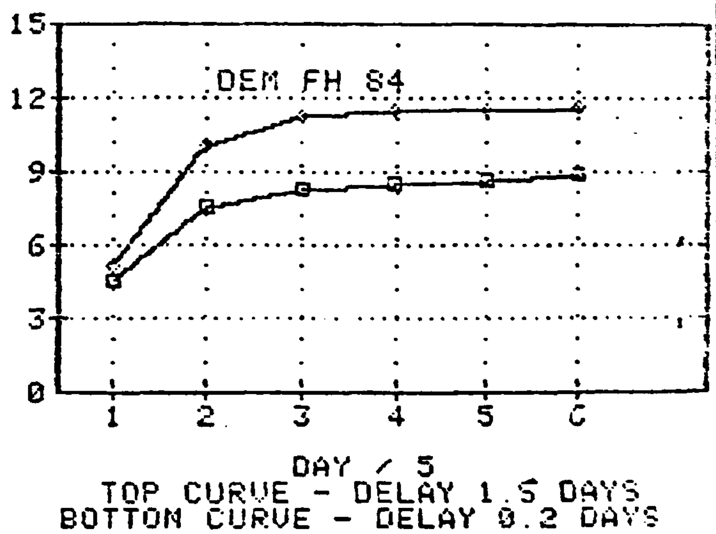
EXPERIMENTAL RESULTS - CONT.





NO CANNIBALIZATION NMCS BY DAY

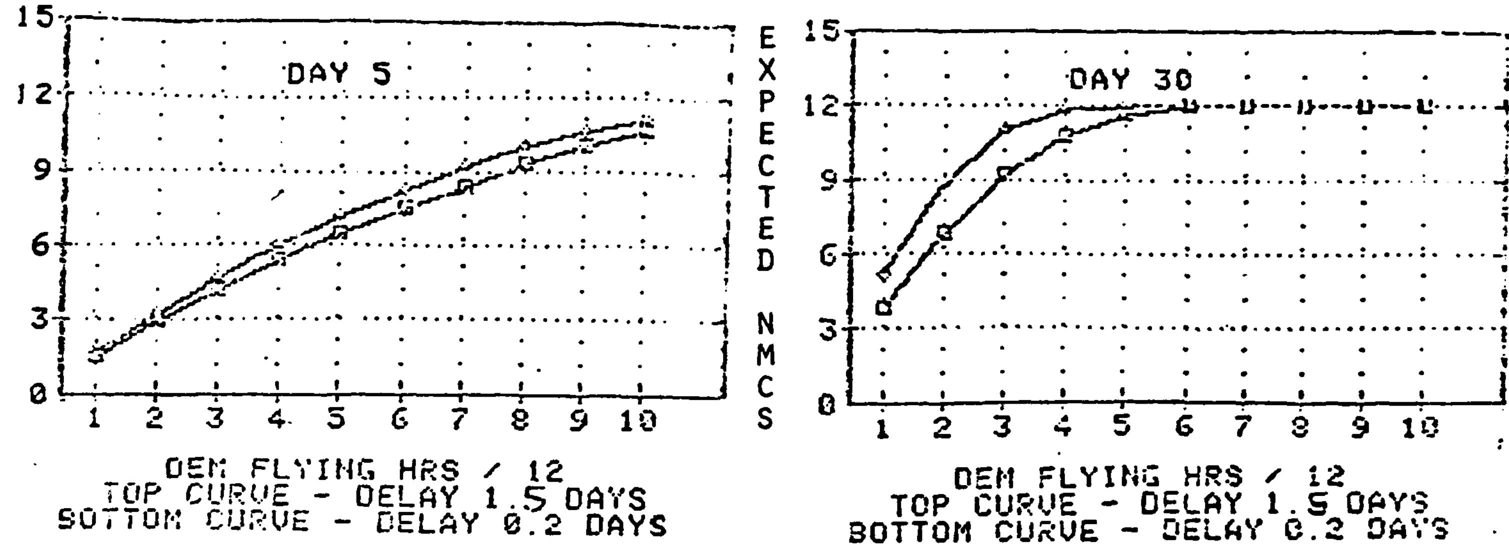




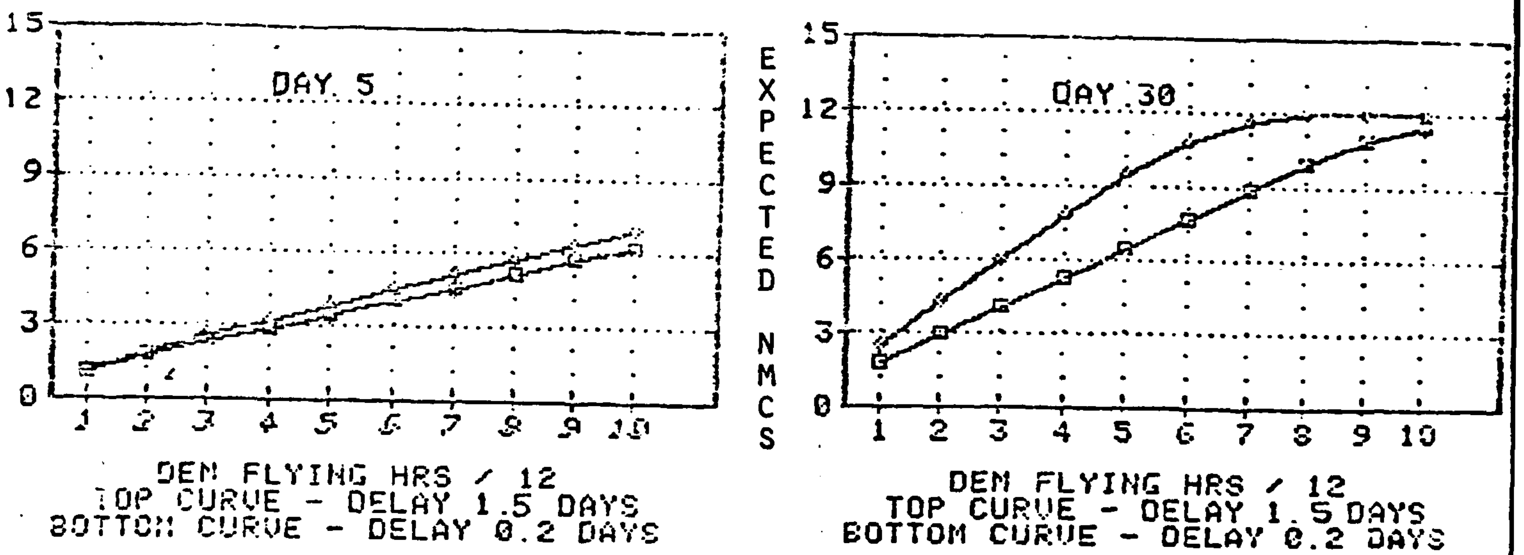
FULL CANNIBALIZATION NMCS BY DAY

FACTORS INFLUENCING NMCS

EXPERIMENTAL RESULTS



NO CANNIBALIZATION NMCS BY DEMANDED FLYING HOURS



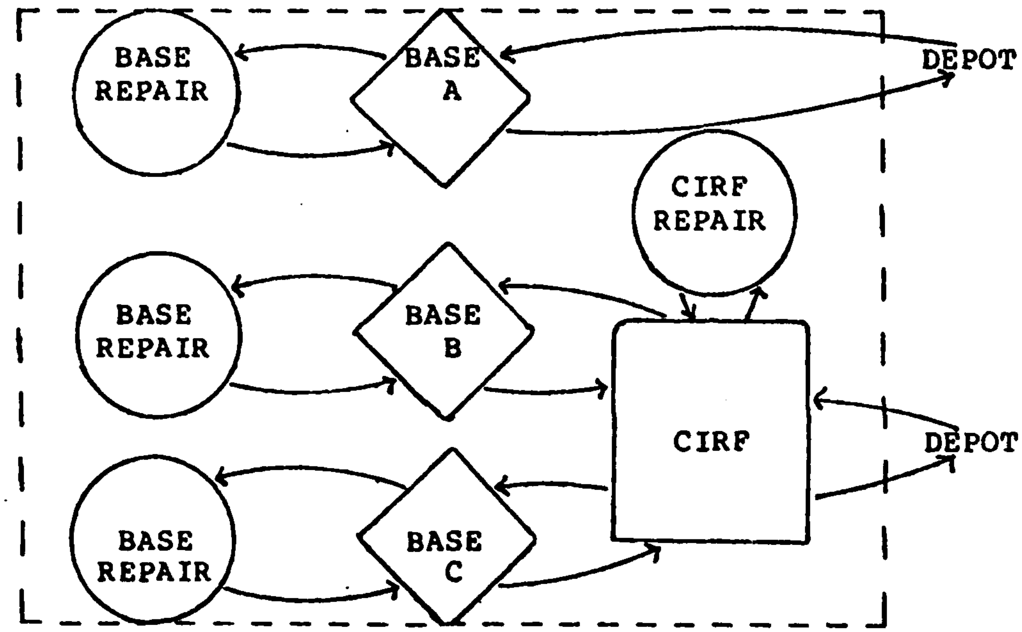
FULL CANNIBALIZATION NMCS BY DEMANDED FLYING HOURS

FACTORS INFLUENCING NMCS

DESCRIPTION OF EXPERIMENT

- IMPLEMENTATION OF ANALYTICS CHECKED
- FACTORIAL EXPERIMENT CONDUCTED
    - TURN RATE = 4.0
    - SORTIE RATE = 2.0
    - FH/SRT = 0.5 TO 5.0 IN STEPS OF 0.5
- MULTIPLE REGRESSION PERFORMED
    - FULL CANN NMCS BY DEMANDED FH AND DAYS

MACRO VIEW OF MODEL

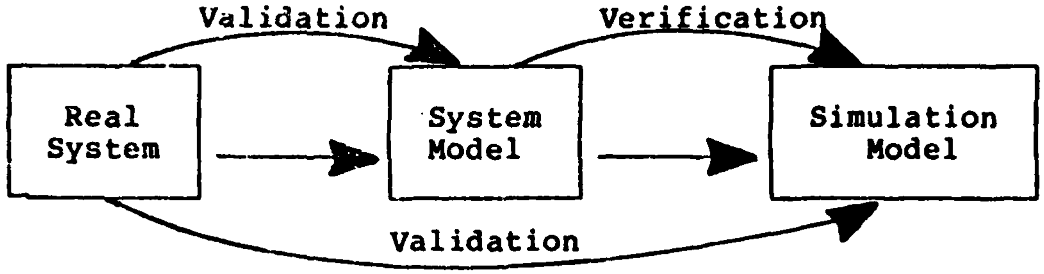


TEST CASE CONFIGURATION

- SINGLE BASE WITH ASSOCIATED CIRF
- CIRF-BASE TRANSIT 0.2 AND 1.5 DAYS
- TWELVE AIRCRAFT AT BASE
- 108 LRUs USED

SCOPE OF STUDY

- VERIFICATION VS. VALIDATION



- LIMITED INPUT PARAMETERS
  - TURN RATE
  - FH/SRT & SORTIE RATE

- LIMITED OUTPUT VARIABLES
  - EXPECTED SORTIES
  - EXPECTED NMCS

- RESULTS SUBJECT TO VALIDATION

OVERVIEW

- INTRODUCTION
    - SCOPE OF STUDY
    - MACRO VIEW OF MODEL
    - TEST CASE CONFIGURATION
- FACTORS INFLUENCING NMCS
    - DESCRIPTION OF EXPERIMENT
    - EXPERIMENTAL RESULTS
- FACTORS INFLUENCING SORTIES
    - DESCRIPTION OF EXPERIMENT
    - EXPERIMENTAL RESULTS
- LRU CONTRIBUTIONS TO NMCS
    - DESCRIPTION OF EXPERIMENT
    - EXPERIMENTAL RESULTS
- SUMMARY

SENSITIVITY TESTING

OF

DYNA-METRIC

MAJOR WAYNE T. GRAYBEAL

AIR COMMAND AND STAFF COLLEGE

MAXWELL AFB, ALABAMA

AWP - THE #1 PARTS PROBLEM

- WHAT HAVE WE DONE?
  - AFLC PROJECT "PACER PARTS" - 1978
    - ASSIGNED PROJECT CODE "AWP" TO REQUISITIONS TO INCREASE VISIBILITY
  - AIRCRAFT TYPE TRACKING FOR SOME SPARES LACKING PARTS
  - TAC/AFLC SENIOR LEVEL READINESS REVIEW - 1981
    - EVALUATED BASE/DEPOT REPAIR PROGRAMS
    - FIRMLY ESTABLISHED AWP AS A MAJOR ISSUE
  - AFLC/LOL FORMED TASK GROUP - OCT 81
    - IDENTIFY AND SIZE PROBLEM
    - SHORT AND LONG TERM SOLUTIONS
- WHAT NEXT?
  - AFLC/LOL TASK GROUP ACTION
  - PROVIDE REAL TIME ITEM MANAGER VISIBILITY
  - RECOGNIZE AWP PIPELINE AND INDENTURED RELATIONSHIP
  - REVIEW REQUIREMENT COMPUTATION OF EXPENDABLE PARTS AT ALC
  - MOVE BEYOND THE AGGREGATE TO THE SPECIFIC
  - ALLOCATE RESOURCES
- AND MOVE OUT TO FIX THE AWP PROBLEM

LG 3964

CONCLUSIONS

- THE AWP PROBLEM IS OUT OF CONTROL
- AFLC IS THE MAJOR SOURCE OF SUPPLY TO SATISFY AWP
  - PRIMARILY BY SRU REPAIR
- RECOVERABLE SUBASSEMBLIES (SRU'S) ARE THE HARDCORE "BAD ACTORS"
- "BAD ACTOR" SRU'S ARE MOSTLY MANAGED BY END ITEM ALC'S/ITEM MANAGERS
- THE SAME PROBLEM EXISTS AT THE TRC'S

LG 3963

REPAIR PARTS CAUSE CODE ANALYSIS

- FOUR AFLC ALC'S ACCOUNT FOR 78% OF UNFILLED DEMANDS
- THE SAME FOUR ALC'S ARE NOT SUPPORTING BASE STOCK LEVELS
  - 77+% OF UNFILLED DEMANDS ARE FOR REPAIR PARTS WITH LEVELS

LG 3961

LRU CONTRIBUTIONS TO NMCS

DESCRIPTION OF EXPERIMENT

- EES = BSL + ER - ED
- ED = D X T X QPA
- ERT = (TESTTIME + BASEDELAY) +

  CBNRTS (2 CBTRANS + CIRFDELAY + TESTTIME) +

  CBNRTS (CIRFNRTS)(OST)
- ERTT = % OF FLYING HOUR PGM IN LAST ERT DAYS
- ER = (1-ERTT) X ED

LRU CONTRIBUTION TO NMCS

DESCRIPTION OF EXPERIMENT - CONT.

- STAGE 1 - ELIMINATE LRUs WITH EES > 1*QPA
- STAGE 2 - ELIMINATE LRUs WITH EES > 0
- STAGE 3 - ELIMINATE LRUs WITH EES > -1*QPA
- STAGE 4 - ELIMINATE LRUs WITH EES > -2*QPA
- STAGE 5 - ELIMINATE LRUs WITH EES > -3QPA
- STAGE 6 - ELIMINATE LRUs WITH EES > -5*QPA
- STAGE 7 - ELIMINATE LRUs WITH EES > -8*QPA

- TURN RATE = 4.0
- SORTIE RATE = 2.0
- FH/SRT = 1 TO 5 IN STEPS OF 1
- CB DELAY = 1.5 DAYS

LRU CONTRIBUTIONS TO NMCS

EXPERIMENTAL RESULTS

- FH/SRT = 2.0   DAY 15

STAGE	NR LRUs	EXPECTED NO-CANN NMCS	EXPECTED FULL-CANN NMCS	EXPECTED SORTIES
0	108	11.46	7.32	17.8
1	80	11.46	7.32	17.8
2	66	11.46	7.32	17.8
3	50	11.38	7.32	17.8
4	34	11.19	7.32	17.8
5	25	11.10	7.32	17.8
6	18	10.97	7.32	17.8
7	11	10.55	7.31	17.8

- OTHER FH/SRT AND DAYS SHOWED SIMILAR PATTERNS.

SUMMARY

- NO PARTICULAR IMPLEMENTATION PROBLEMS NOTED.
- HEURISTIC APPEARS PROMISING TO MINIMIZE SIZE OF INPUT DATA SET.
- RESULTS NEED VALIDATION.
- COMPLETE REPORT CAN BE OBTAINED FROM:

  ACSC/EDCC
  MAXWELL AFB, ALABAMA 36112

SPECIFY STUDENT REPORT #82-0970

A WARTIME PUSH SYSTEM FOR SPARE PARTS

BY

LT COL ROBERT S. TRIPP

CHIEF, READINESS INITIATIVES GROUP

OGDEN AIR LOGISTICS CENTER

A WARTIME PUSH SYSTEM FOR SPARE PARTS

BY

LT COL ROBERT S. TRIPP

CHIEF, READINESS INITIATIVES GROUP

OGDEN AIR LOGISTICS CENTER

This purpose of this paper is to acquaint the reader with the efforts we've made at Ogden to establish a wartime push system for spare parts.

Problem and Background

With the exception of the prototype effort which is being accomplished at Ogden, the ALCs have no method to predict wartime spares requirements during surge and sustainability periods of conflict. As a result we have no plans to resupply war zones with follow-on requirements. Instead of developing forecasts of expected follow-on spares lists and developing plans to insure these spares are sent forward to the battle zones, we plan to rely on the combat commands to tell us what they need to pursue the war. This may be an impractical method of doing wartime resupply for the reasons outlined below.

As the agent responsible for the supportability of his assigned weapon system, the System Manager (SM) is, by default, responsible for providing effective depot level logistics support for his weapon system to wartime theaters or battle zones. To determine the type of information, the SM needs to direct wholesale or depot level logistics support efforts in time of war, we must begin with a description of the war scenario(s) we expect to encounter. From the scenario, we can derive the nature of logistics support required, which in turn, determines the wholesale system support role. Once this role is outlined, we can compare our requirements with the current state of the wholesale support system. Following this comparison the specific role of the SM can be outlined as well as the information he needs to accomplish his job.

After the SM wartime job and his resultant information flows are established, we can compare these requirements with his current role and the information he receives. From these comparisons in the information area, we can identify data requirements and take steps to develop sources of data we don't currently receive. From an organizational perspective, our analysis will help define the policies and procedures which need to be developed for the SM to function in his wartime role.

The most difficult wartime environment for the wholesale logistics system to support is the high intensity dynamic conventional war like that envisioned in a NATO conflict. In this environment, with the very real probability of damage to our base support structures and communications, it is likely that our wholesale support system will have to be attuned to nonstandard operations. The movement of forces is likely to occur quickly and priorities for support will change from one location to another as the flow of battle changes. We need to keep abreast of these force movements and priorities to move supplies to the right part of the battle area in our resupply actions. We need to be prepared to reallocate resources destined for one theater location to another in a timely manner. Therefore, we must make sure we know about the movement of forces and changes in priorities.

With potentially large scale communications disruptions, logistics requirements may not be fully transmitted to the wholesale system. We must anticipate this shortcoming and take steps to be able to predict where and when resources are required without a fully operational communications network.

Finally, nonprogrammed sortie requirements, quickly changing unit priorities, and movements to nonprogrammed locations dictate that we have a strong weapon system management organization to tie CONUS support to changing theater requirements.

The major problem we face in the wholesale world is that our current system has been designed to support a stable force bed-down structure with stable priorities and predictable demand rates. In essence, we have a largely peacetime oriented structure which is based on full communications of logistics data and processing of supply requisitions on a first-in, first-out basis for requisitions of the same priority. This is not a very realistic view of what we might expect in a high intensity war. Yet this is the system which we assume will be functional in our war planning exercises.

To make the situation even worse, weapon system support is fragmented between Air Force Logistics Command (AFLC), Defense Logistics Agency (DLA), and other services. Currently, there is no coordination of support efforts to a specific wing or squadron. The standard base supply system cuts requisitions for items and automatically dispatches them to the source of supply for that item. Upon receipt of requisitions, each ALC or DLA depot acts independently on filling requisitions. In peacetime situations, this approach contributes to an efficient whole/base level support system. However, in a high intensity conflict this system would completely breakdown without adequate communications. Even if full communications were established, the current system could not cope with fast changing priorities and movements of forces. There is no single point which can coordinate the rapid movement of wholesale logistics support for a given squadron envisioned in our scenario.

From the preceeding discussion you can see that if we are to provide effective wholesale logistics support in a high intensity conflict, we need to have a single integrating manager responsible for delivering support to each weapon system. More specifically, in a wartime environment there are three major functions the single integrating wholesale manager needs to accomplish. These are: (1) He needs to determine/project wholesale support requirements; (2) he needs to determine availability of required assets; and (3) he needs to allocate/reallocate and push required assets to the battle zones.

In order for the SM to carry out these functions, he needs to have access to information he currently does not receive. He must be able to predict support requirements, assuming disruptions in communications coming from the battle zones, he then needs to influence allocation/reallocation decisions of resources and keep track of where he is obtaining resources to satisfy highest priority requirements. In these situations he may be forced to "rob from Peter to pay Paul" and he needs to keep books on how these decisions impact the fighting and residual forces. To accomplish these tasks, the SM needs to have a decision oriented interactive data base that will show him shortage impacts on all engaged and non-engaged forces resulting from resource allocation decisions.

Designed Solution

At a minimum the SM must be able to accomplish the following functions:

.Track force deployments/redeployments

.Predict Not Fully Mission Capable (NFMC) rates and sortie
.generation capability

.Predict "sortie limiting" shortages

.Push shortages

.Track allocation decisions

..Distribution/redistribution

..Repair

The one element of information we must have involves force deployments/redeployments. Given this information, a data base can be constructed to insure adequate resupply is moving to battle zones. Before hostilities begin, current war plans involving the movement of forces need to be loaded into our computer. This information tells the SM what units are to move to what locations at specified times. During hostilities, we must be informed as to changes in force locations. Once we have these changes we can track force movements which is the key to delivering required support. In other words, as we are about to show you, we can live with cut offs in logistics information flows, but we must obtain information on the movement of forces and their priority for support from the war zone. It seems reasonable to assume that complete communications will not be cut off and we need to make arrangements now to insure we can obtain force movement data. The best source might be the Worldwide Military Command and Control System (WWMCCS).

Next, the wartime data base must identify War Readiness Space Kits (WRSK) shortages by squadron. Our current WRSK status system (LOGRCS 7180 report) reports WRSK shortages by unit once each month. By the time it is received at our ALCs the data is 45 days old and the status of the WRSK is certain to be different from that which was reported. Fortunately, the Combat Support Management System (CSMS)1 addresses this short fall and AFLC is laying plans for the ALCs to participate in this system.

Once the war starts however, this source of information which uses 1050II data may be incomplete as communications are disrupted. Therefore, our Push system must be capable of predicting squadron WRSK shortages after communications are severed. Again, this is not a difficult problem to deal with and Dyna-metric2 can be used to predict unit shortages over time.

In this system design the SM tells the IM the quantities of items that need to be pushed. the IM is held responsible to find locations and status of available assets. With this knowledge the IM can reallocate assets to satisfy shortages of the highest priority units. Let's emphasize that the intended use of this Push System is to provide information on requirements in the battle zone and availabilities of assets in the CONUS so that we can push assets to the battle zone in the right quantities to support the war effort. We do not intend to establish in-theater visibility. We are too far away from

the minute to minute decision making to be effective. Our job should be to push assets to the theater for on the spot allocation by theater commanders. It seems reasonable, however, that the in-theater logistics decision makers could use a system like this for their allocation decisions.

Finally, we rely on the Item Manager (IM) to keep track of allocation/reallocation decisions. The SM must know who he's borrowed from and current status of shortages/availabilities which result from his decisions.

Figure 1 shows a schematic of the designed solution. The solution design is similar to the previous application. This figure illustrates how we predicted sortie limiting shortages by using the Dyna-metric model. The upper left hand box shows the inputs we used to make our wartime scenario. Our first application of the approach was used in support of a specific PACAF exercise (Ulchi-Focus Lens 81). This scenario information along with PACAF F-4 sortie duration and attrition rates were used to project sortie limiting items. The box directly underneath the wartime scenario shows the types of logistics information the model requires. We then fed the wartime scenario and logistics information into the Dyna-metric model and the resultant outputs gave us predicted sortie rates, NFMC rates, and item shortages. We then compared the outputs with the warplan. If the number of sorties generated by the model was greater than, or equal to the warplan, we had adequate spares and did not require any resupply. If the number of sorties were less than the warplan requirements, we noted the item shortages and had to push assets to the battle zone to meet the warplan sortie requirement.

During the exercise we identified push by exception items. Pareto's Law operated again in this effort and there were very few items which cause NFMC aircraft to go above our present threshold. We were granted authority by HQ AFLC for the F-4 SM to direct the IM to direct distribution, repair, and procurement actions for these item shortages. We then pushed the items to meet the requirements of the scenario. Additionally, the SM coordinated the total ALC effort to make sure the spares got to PACAF when they were needed. If an ALC couldn't meet the requirement, the SM provided specific guidance on what each ALC could to to help satisfy the requirement.

Inputs and Outputs: Comments & Illustrations

Figure 2 shows some of the major data inputs and their source.

Figure 3 is an example of the kinds of outputs we can get. For the F-4G, this chart shows percent not fully mission capable (NFMC). NFMC is defined as an aircraft with a hole in it, and the part is not on the supply shelf or is in maintenance awaiting repair. The NFMC rate does include partial mission capable aircraft, so it's a conservative estimate. With no push or depot resupply, the scale gives you percent NFMC versus day of the war. What it says is that if you don't have assets in place by day 60 of the war, 65% of the airplanes will be down.

Dyna-metric identified the items which limit performance above an arbitrary 15% NFMC threshold. Examples of these items are show in Figure 4. This is a listing of the items which will cause us to have a greater than 15% NFMC by day of the conflict. With this information, we can set up plans to get the specific items to the battle zone before they become short.

Figure 5 shows cumulative sorties versus day of the war. We take the

PUSH SYSTEM
DESIGNED SOLUTION

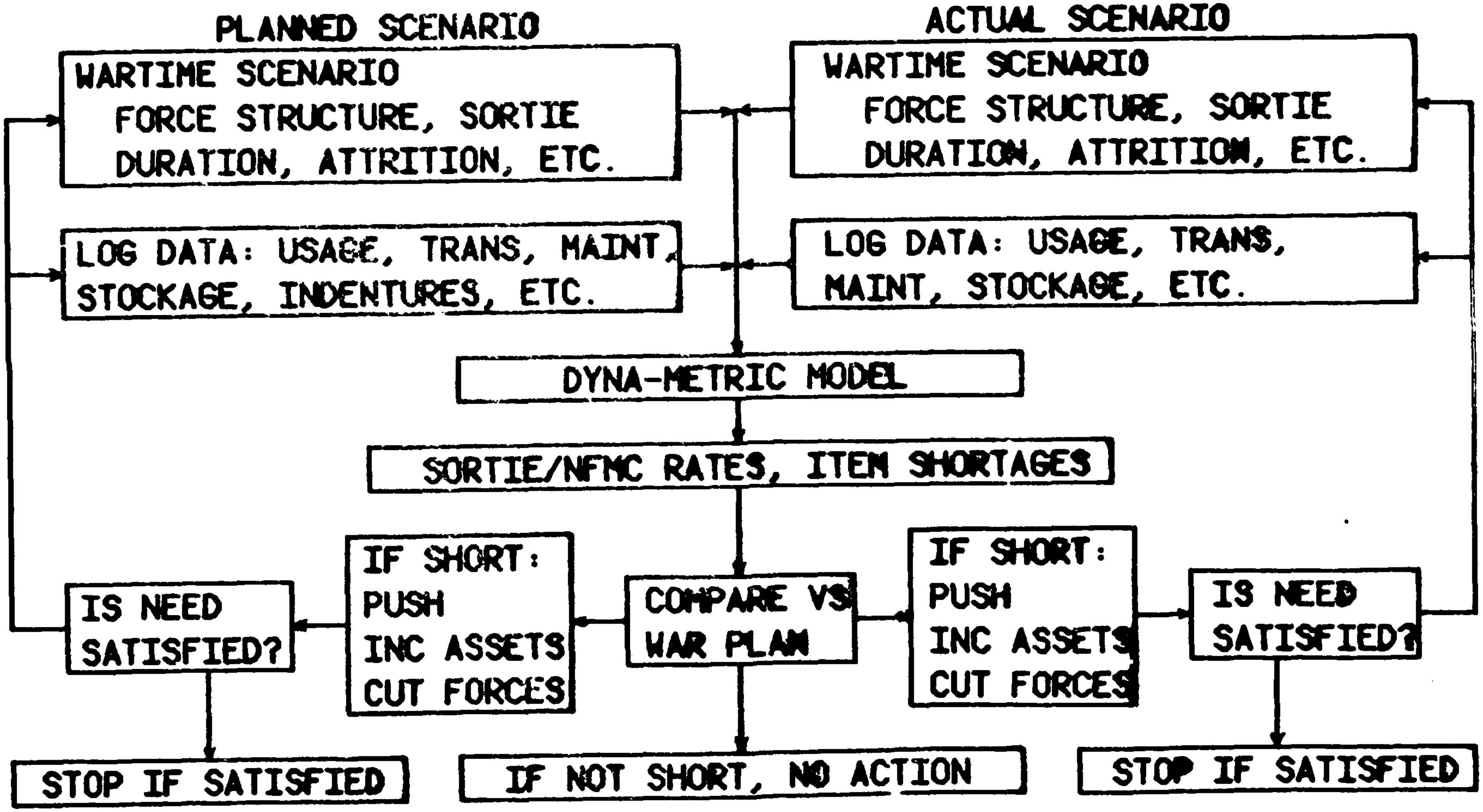


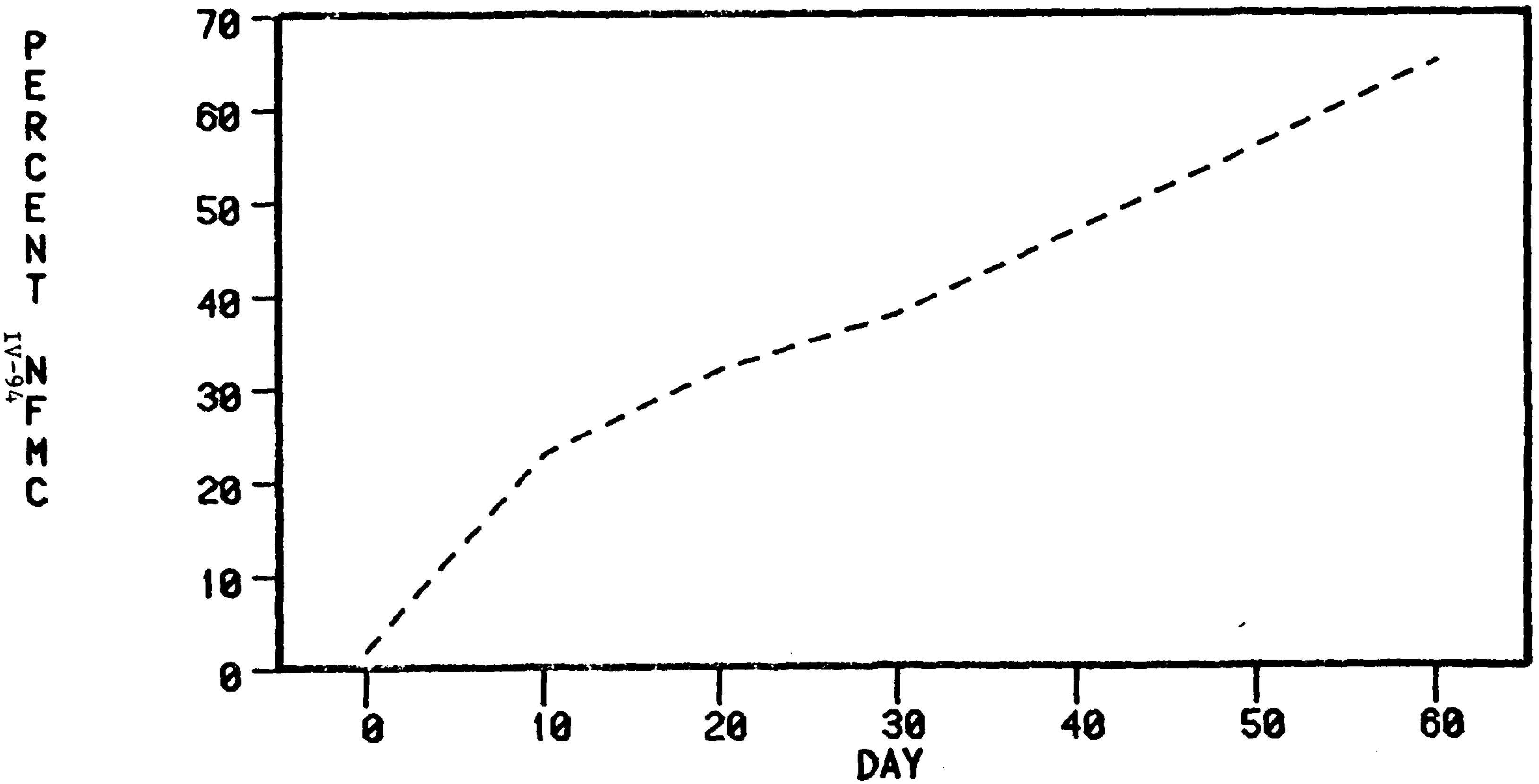
FIGURE 1

INPUTS

SOURCE	DATA ELEMENTS
WAR PLANS (THE OBJECTIVE)	WARTIME SORTIES REQUIRED TASKED UNITS BEDDOWN STRUCTURE ATTRITION RATES
WARTIME SPARES COMPUTATION SYSTEM (D029) (THE LOGISTICS PLAN)	PLANNED DEMAND RATES PLANNED REPAIR TIMES/CAPABILITIES LRU/SRU RELATIONSHIPS PLANNED ORDER AND SHIP TIMES PLANNED STOCKAGE LEVELS
BASE LEVEL SUPPLY SYSTEM (THE LOGISTICS PLAN) (EXECUTION - ACTUALS)	ACTUAL DEMAND RATES ACTUAL REPAIR TIMES/CAPABILITIES ACTUAL ORDER AND SHIP TIMES ACTUAL STOCKAGE LEVELS

FIGURE 2

EXAMPLE OUTPUTS
F-4G PERCENT NOT FULLY MISSION CAPABLE (NFMC)



NO PUSH	2	23	32	38	47	56	65	---

FIGURE 3

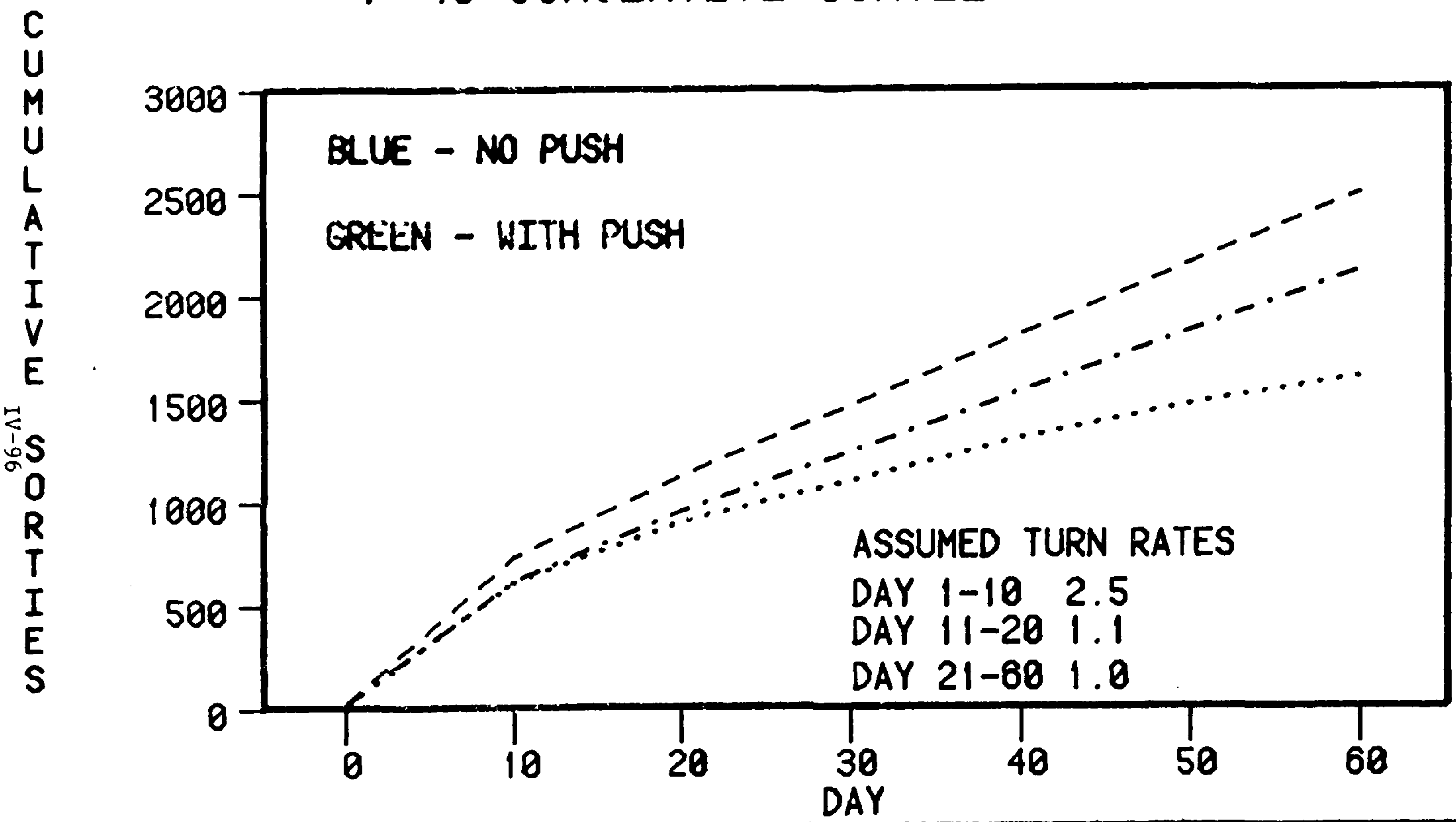
EXAMPLE OUTPUTS

F-4G PROBLEM ITEMS BY DAY

WUC	SYSTEM	NOUN	ALC	DAY 10	DAY 30	DAY 60
71H20	RADIO NAVIGATION	COMPUTER, NAV	OC	2	7	15
73160	BOMBING NAVIGATION	DISPLACEMENT, GYRO	OC	0	2	7
74910	FIRE CONTROL	OPTICAL DISPLAY UNIT	WR	0	4	8
74BP0	FIRE CONTROL	WAVE-GUIDE ASSY	OO	6	10	18
74BV0	FIRE CONTROL	ANTENNA	OO	5	12	22
76BB0	ECM	CONTROL - IND, PANORAMIC	WR	4	4	7
76BG0	ECM	POWER SUPPLY	WR	0	0	4
76BL0	ECM	RECEIVER, RADIO	OC	0	5	12

FIGURE 4

EXAMPLE OUTPUTS
F-4G CUMULATIVE SORTIE PROFILE



REQUIRED	30	738	1134	1476	1818	2160	2502	— — —
GENERATED	30	628	918	1119	1324	1487	1618	· · · · ·
GENERATED	30	628	984	1255	1545	1836	2127	— · — ·

FIGURE 5

STRUCTURAL MODEL
WORKORDER ASSIGNMENT

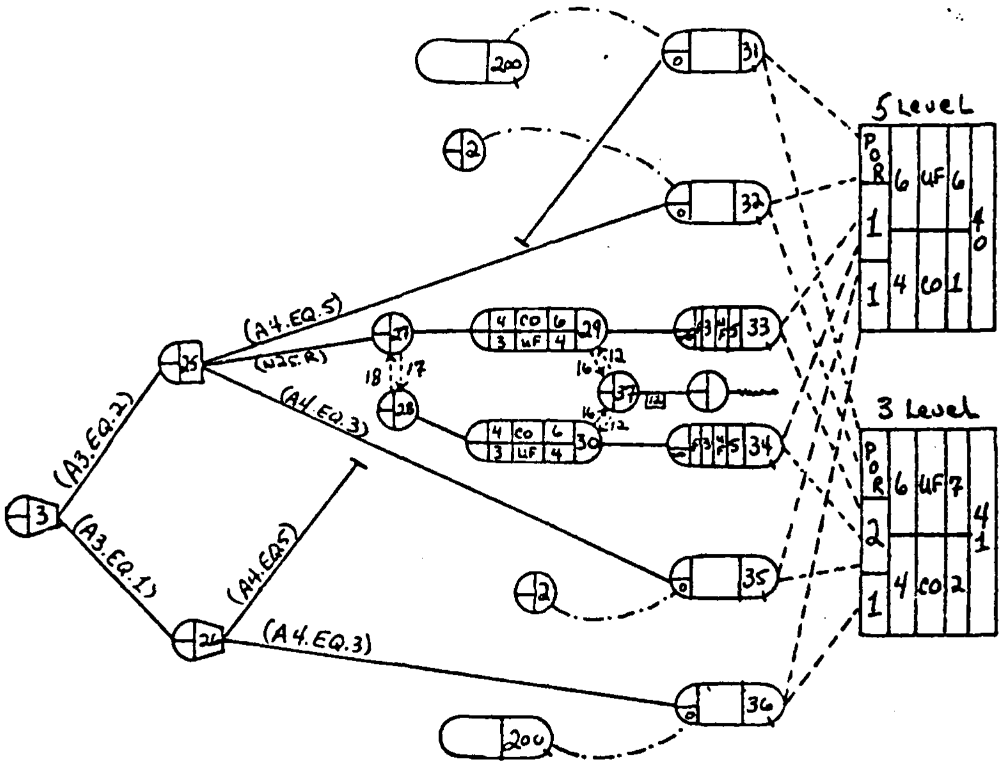


Figure 9

STRUCTURAL MODEL
WORKORDER ASSIGNMENT

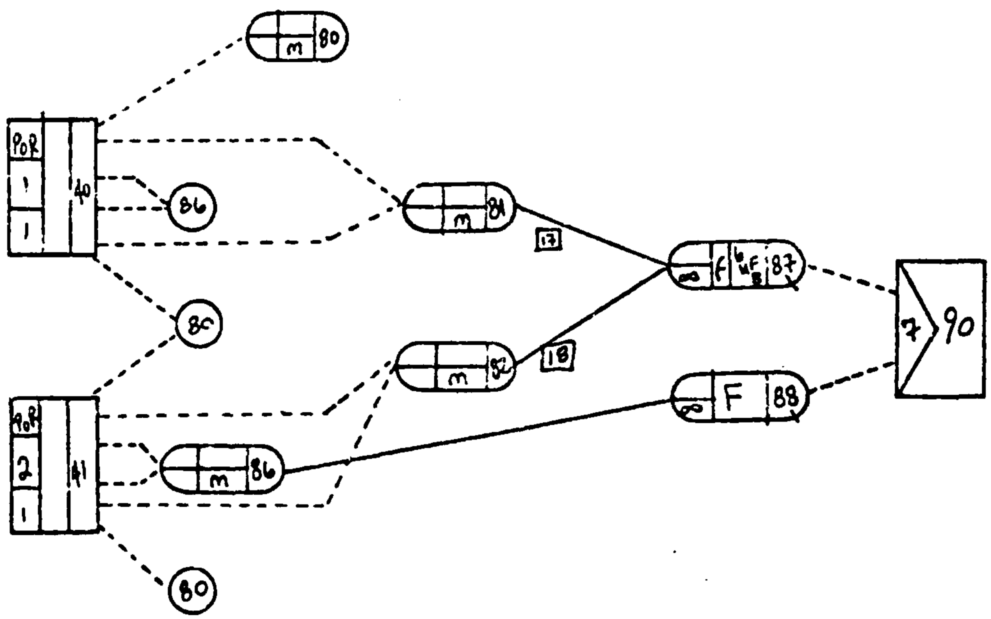


Figure 10

STRUCTURAL MODEL

TRAINING ACTIVITY

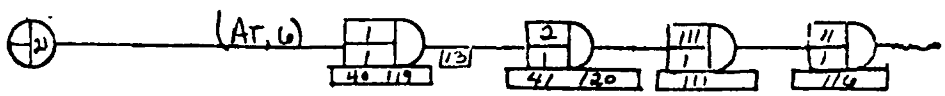


Figure 8

The training records are simultaneously updated in Figure 7 by sending a duplicate transaction through node 24 (note, this transaction is killed if the trainer resource is not available at allocate node 119). This duplicate transaction is then assigned a sequencing number which is incrimented by 1 each time a transaction comes through. This is essentially a counter on the number of training repetitions the trainee has accumulated up to this point in the simulation. This number is then compaired to the required number of training repetitions required before the trainee can be qualified. If the threshhold has been met for trainee qualification, the the transaction will be routed to the alter node which depletes the corresponding dummy resource. Further training is thus eliminated for that trainee on that system/task combination.

Workorder Assignment Activity (Figures 9 and 10)

This section covers the general resource assignment decision process which occurs if training is not conducted, for one reason or another. The supervisor first notes the crew size required by the workorder and the minimum skill level requirements of its task. The model distinguishes these two items through a series of sort decisions at nodes 3, 25 and 26 (Fig 9). Node 3 separates the one man and two men tasks according to the transactions crew size attributes. Nodes 25 and 26 separate the 5-level tasks from the 3- level tasks similarly. (The 5 and 3 level refers to the AFSC awarded skill level the technician receives as part of the upgrade training program.) Once these transactions are sorted, the workorder is ready to be assigned to a maintenance technician. When assigning the workorder, the workcenter supervisor will take note of the technician's technical abilities and try to match the task difficulty to a technician with comparable abilities. The basic objective behind this matching process is to minimize the average task times of all tasks through the workcenter. (A mismatch of an inexperienced technician with a difficult task will result in an excess repair time) The smaller the workorder repair times will improve the workcenter's maintenance capability standing.

The decision of which technician to assign to the workorder depends on how many technicians are available and the ability level of these technicians at the time the workorder comes through the workcenter. If the technicians are available, the the supervisor will make the assignments according to the

If the trainee in question is available, then the transaction is routed to the next portion of the training activity (node 5, Fig 7) which checks to see if there is a trainer available. (Note, that the model returns the unwanted dummy resources allocated in the previous networks back to their previous state. This is done with nodal modifications which are keyed to previous network activities between the dummy resource allocate nodes and the trainee allocate nodes in figure 5. If the nodal modification is actified, then nodes 18 and 19 in figure 7 will be modified in order to route the duplicate transactions to the respective networks in figure 6 to free the unwanted dummy resources. Extreme care has been taken to insure only the desired resources are allocated in the training activity.) If the trainer is not available at allocate node 119, then the transaction is balked to node 20 (Fig 7). The transaction then frees the previously allocated resources and is sent to the general resource assignment activity (node 3). If the trainer is available, then a general trainee resource is assigned. (This general resource is used in the general resource assignment activity and is assigned here to insure that all resources are accounted for. This is to prevent misassignment of an already allocated resource.)

Once all the appropriate resources are assigned, the transaction will be routed to the task accomplishment section of the training activity (Fig 8). Here the transaction will be tied up for the duration of the training task time assigned to the transaction at allocate node 119 (Fig 7). Once the time period is up, the task is completed and the transaction frees the appropriate resources and leaves the network model.

STRUCTURAL MODEL
TRAINING ACTIVITY

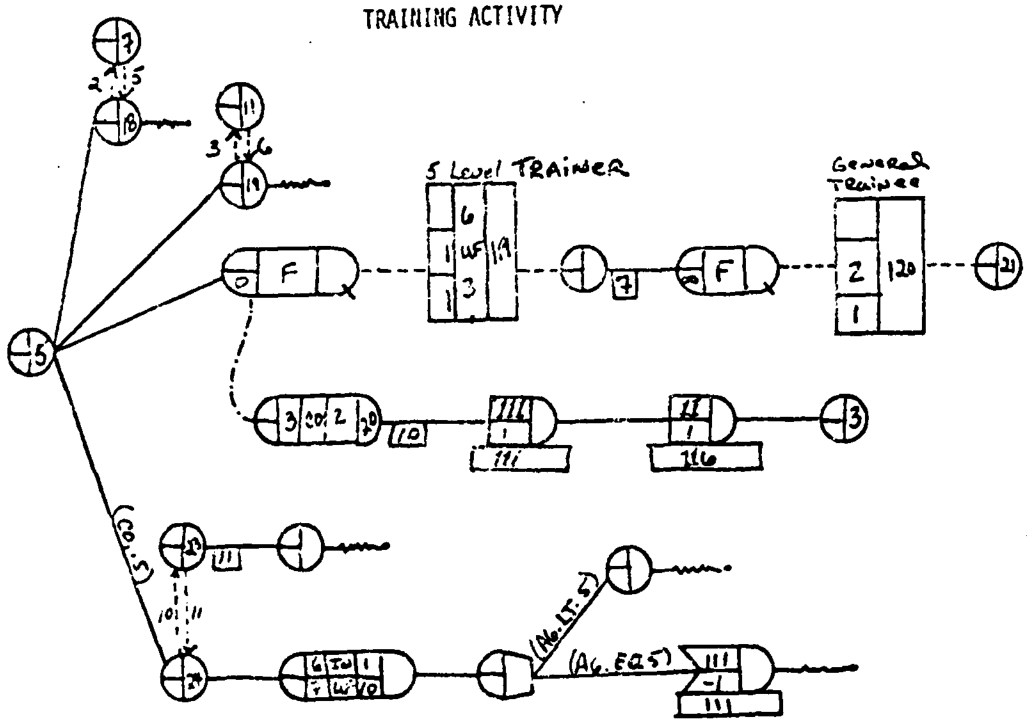


Figure 7

STRUCTURAL MODEL
TRAINING ACTIVITY

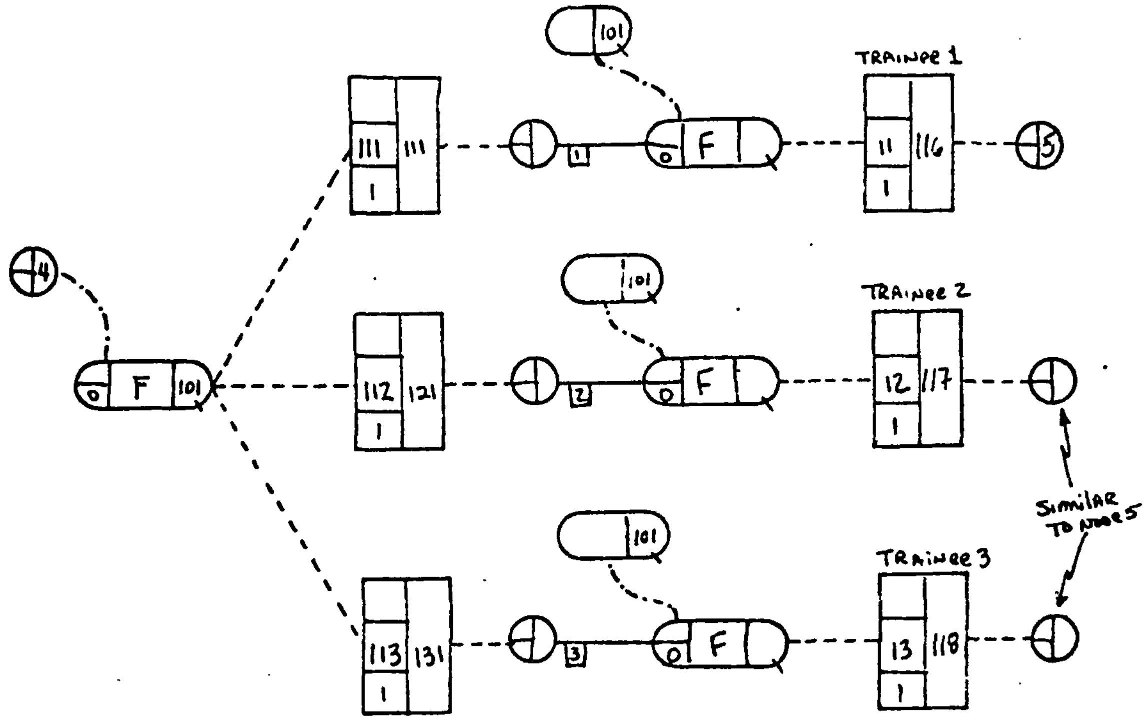


Figure 5

STRUCTURAL MODEL
TRAINING ACTIVITY

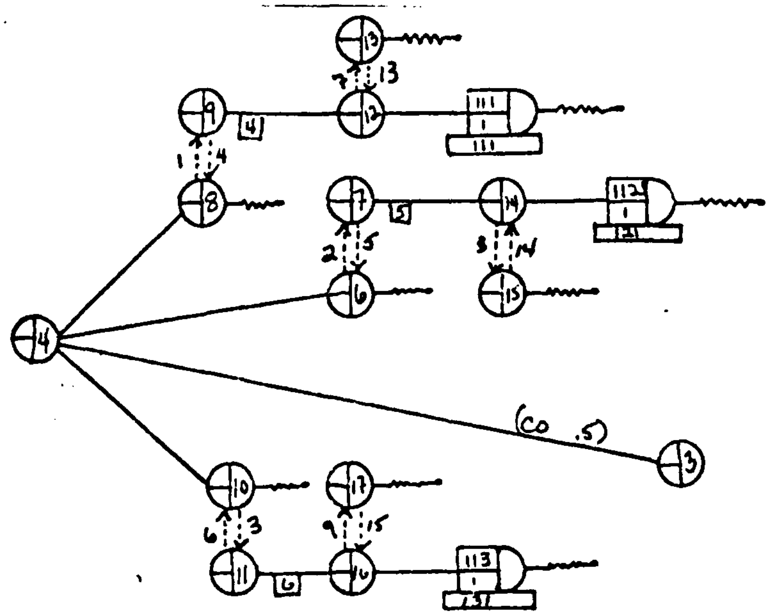


Figure 6

STRUCTURAL MODEL
TRAINING ACTIVITY

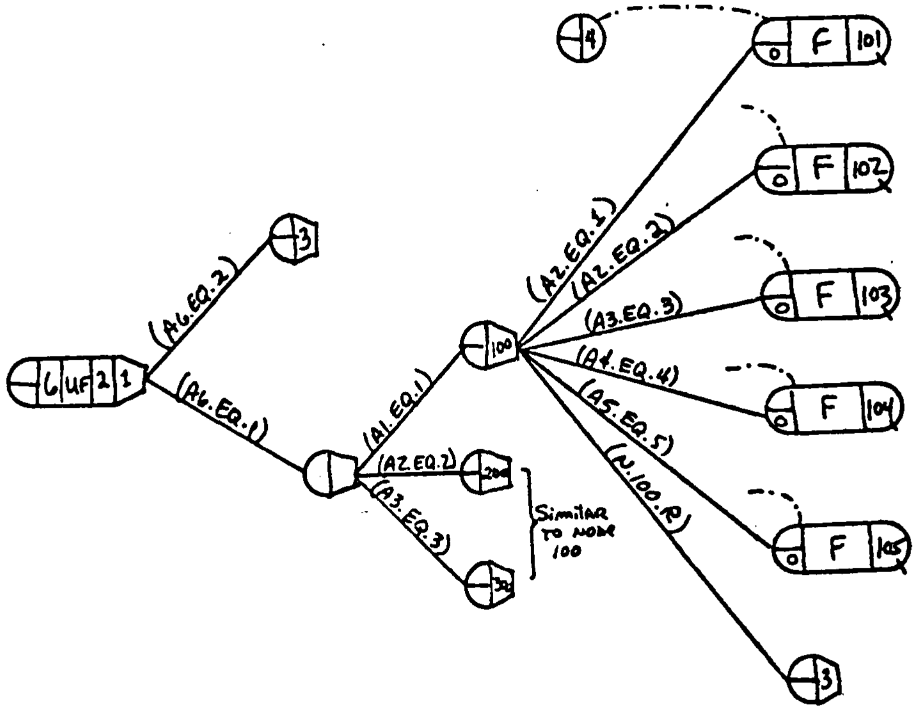


Figure 4

unsuitable for training and the transaction will be sent to the general resource assignment activity (node 3).

From queue node 101 (Fig 5, note, the other system/task training networks operate the same as this), the transaction checks three allocate nodes to determine which trainee requires training on this system/task. These allocate nodes (111, 121, and 131) act as on/off valves for access to the subsequent networks. The dummy resource (only one) assigned to each of these allocate nodes represent each trainee's need for training on that system/task. The resource (111,112, or 113) is unique for each trainee and system task combination. Once the trainee is qualified, the dummy resource associated with that trainee on that system/task will be depleted, thus preventing additional training for that individual on that system/task.

Once through this initial allocate node, the transaction checks to see if the corresponding trainee resource is available. If not, the transaction is balked back to queue node 101 where it checks the other trainees' needs and availability. If training can not be conducted, then the transaction is balked from queue node 101 to node 4 (Fig 6), where all the dummy resources which have been allocated for this current transaction are restored back to their previous status. The transaction is then routed to the general resource assignment activity (node 3).

STRUCTURAL MODEL
WORKORDER EVALUATION

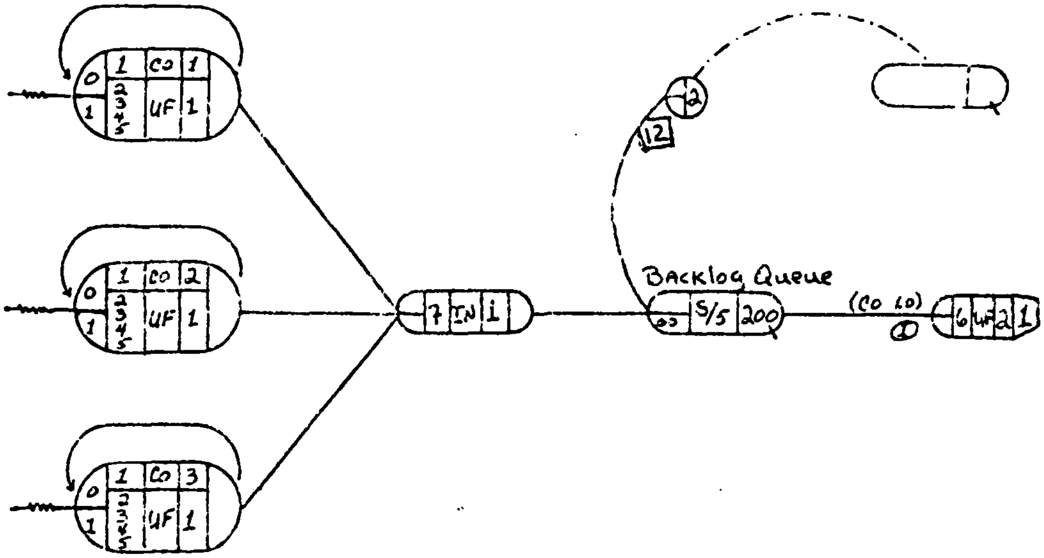


Figure 3

<u>Training Activity</u> (Figures 4 thru 8)

The training decision process involves the following steps:

- -Determine if the workload permits training.
- -Determine if the task is suitable for training.
- -Determine if there is a training need.
- -Determine if the trainee and a trainer are available.
- -Assign these resources to the workorder.

Once these steps have been staisfied, then the appropriate training will be conducted and the workorder completed. The training records on the individual trainee will then be updated. If any step is not satisfied, then the resources will be assigned to the workorder in a no training (general) context. This general resource assignment activity will be discussed later.

This training section of the model is based on the need to accumulate so many task specific training repititions before the trainee is qualified on that task. Once qualified, the trainee will need no more training on that task.

To accomplish the first step, above, the model evaluates the number of workorders in the backlog queue. This is done at node 1 (Fig 4). If there are a lot of workorders (actual threshhold is workcenter dependent), that will indicate that the workcenter is too busy and does not have enough time to conduct training. When the workcenter is too busy, the workorder transaction will by-pass the training networks and will be sent to the general resource assignment activity (whose entry point is node 3). If the workload permits training, then the transaction will be directed to the set of networks which cover the training for the particular system/task combination defined by the attributes assigned to the transaction.

Queue nodes 101 through 105 (Fig 4) represents the training network entry points for each of the five task types on system 100. If the task on this system does not fall in these five categories, then that task has been determined to be

STRUCTURAL MODEL

SYMBOLS

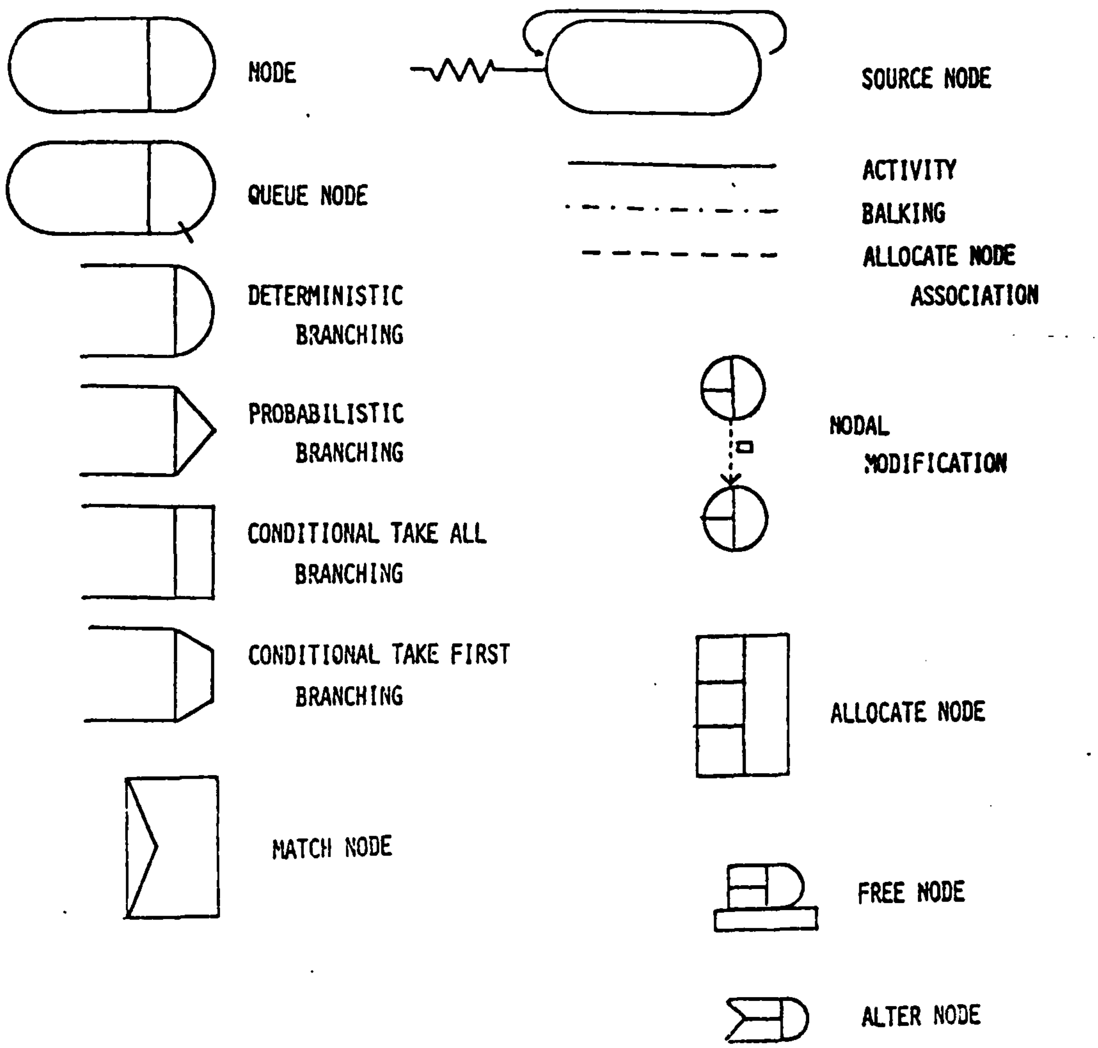


Figure 2

difficulty is determined (whether an experienced technician is needed or whether an inexperienced technician could do the job). Finally the workorder priority and the crew size (one man or two man task) is determined. The source nodes in Figure 3 each represents a system and the workorder transactions are generated based on a mean time between maintenance actions (MTBMA) distribution experienced by the workcenter on each system. The workoder attributes discussed above are assigned at the source nodes. These transactions are then processed through a node which assigns a workorder sequence number and then on to a workorder backlog queue. The workorders are then arranged according to their priority and released one at a time to the next activity in the structural model--training activity. Note that the transactions which can not be satisfied further on in the model are balked back to the backlog queue.

standing of the concept of productivity. Productivity is a measure of the amount of work done per unit of time. One item left out most, when defining productivity, is the concept of quality. The work output must be classified somehow according to its quality, and then the productivity measure must be adjusted accordingly. For instance, if two technicians perform the same amount of work in the same time but the quality of their work is different, then the technician turning out the higher quality work is the more productive of the two technicians. The driving factors in an individual's productivity level are experience and training background. Therefore, based on the individual's past experience and training, the technicians productivity will vary based on how fast the technician can perform and what quality the work is. (Note: Because of its extreme complexity, motivational factors are disregarded for this paper.)

One other area must be addressed in looking at productivity and that is the technicians under going some type of on-the-job training. These individuals are not fully productive. Besides this, the training process takes additional productive time away when the qualified technicians have to spend time training these individuals. Now besides the task time differential and quality of work, the on-the-job training workload must also be considered when evaluating the manpower resources impacts on the workcenter's capability.

The next section on the workcenter structural model will address the above three factors on individual productivity--task times, work quality, and on-the-job training. The structural model will look at how maintenance demands are processed through the workcenter and the decision processes used to assign differently skilled technicians to jobs and the decision processes used to conduct training.

Structural Model

The structural model presented in this section is illustrated using Alan B. Pritsker's Q-GERT (Queueing Graphical Evaluation and Review Technique) symbology. For your convenience, Figure 2 is provided as a breif introduction to the Q-GERT symbols used in this paper.

The structural model will be divided into four activities--work order evaluation, training, workorder assignment (without training), and task performance (including the quality implications). These activities represent the receipt of a maintenance demand, referred to as a workorder; the processing of that workorder, on to the final workorder completion and exit from the workcenter. For purposes of this paper, all resources other than the manpower resource will be assumed unlimited. This is done to concentrate on just the manpower skill level issues.

Workorder Evaluation

This first activity is shown in Figure 3. When a demand is placed on a workcenter, the supervisor first evaluates the workorder to determine its attributes. First, is the determination of what system the work is on and what the task is (ie. troubleshoot, repair, remove and replace, etc.). Next the task

dynamic variable influencing maintenance capability, and its impact is profound. The dynamic nature of the manpower resource is do to the constant rotation of technicians in and out of a workcenter. This complicates the impact on maintenance capability because with a reassignment the workcenter loses a weapon system experienced technician and usually receives an inexperienced technician or a new recruit directly out of tech school. Both of these new resources require on-the-job training before they are fully productive members of the workforce.

The experience level and skill composition of the workforce is therefore continually changing do to this constant rotation and retraining process. Much has been done to quantify the impact of spares and equipment on maintenance capability, but currently, little has been done to quantify how the changing workforce impacts capability. The maintenance manager needs a timely and effective procedure for quantifying this impact and assessing the current and future capabilities of his assigned workforce.

This paper will investigate this relationship between the workforce skill composition and will present a strucural model of a workcenter which highlights this relationship. This model can then be computerized and provide a simulation framework for assessing the skill level effects on maintenance capability.

Conceptual Model

As stated earlier, the goal of a maintenance program is to provide the maintenance capability required to meet the mission. This is done by sizing up the flying requirements established by Operations and then developing the maintenance capability to accomplish these requirements. Of course, maintenance capability does not materialize overnight. So the process of accomplishing this primary goal occurs in an iterative manner. So each step of this process will re-assess maintenance capability. If this capability is insufficient to meet Operation's requirements, then these requirements will be constrained by the maintenance requirements, which are driven by maintenance capability (see Figure 1). The actual constraining function occurs when Operations and Maintenance sit down to negotiate a flying schedule. Out of this meeting comes a firm flying schedule and maintenance plan. This flying schedule and maintenance plan drive the number of demands which the individual workcenters must satisfy. How well that workcenter performs in meeting these demands will determine the actual amount of flying accomplished (how well the mission requirements were met) and will provide more feedback on what the maintenance capability is. Both the re-assessment of maintenance capability and of the mission accomplishments will in turn drive the Operations and Maintenance requirements at the next scheduling meeting.

It is the workcenter section of this Conceptual Model which is of prime concern for this paper. The major interest is looking at the manpower resource with its skill level attributes and how this resource impacts the workcenter's performance.

In evaluating individual technician performance, one must have an under-

Now, how does one determine if the required maintenance capability has been obtained? And, whether it can be sustained? Even more so, in a base level maintenance production environment, how does the maintenance manager assess current and future maintenance capability so that an effective and efficient flying/maintenance program can be established? In this situation, the maintenance manager must know the abilities of each individual technician and piece of equipment. The manager must understand how all the people and equipment interact to produce maintenance, and what their overall production rate is. Once the manager has assessed the group's production abilities (maintenance capability), the maintenance plan and flying schedule must be developed so as not to generate more demands than the current maintenance capability can handle. Also, the maintenance manager must identify the current shortfalls where maintenance capability is not meeting mission needs. In these shortfall areas, specific problems must be identified and solutions found in order to strive for the needed maintenance capability. These problems could be anywhere from inexperienced technicians, who require additional training, to lack of test equipment or spare parts. Essentially, the maintenance manager's job of establishing the required maintenance capability, has not ended until the maintenance production can be sustained at the level needed to fulfill mission needs. And, most often, this can be achieved for only short periods of time. This process is illustrated in Figure 1 below.

As one can see, this concept of establishing maintenance capability is not simple. In fact, the process of assessing maintenance capability is very dynamic when one considers that the resources available to maintenance is constantly changing. In particular, the manpower resource is the most

CONCEPTUAL MODEL

MARCO VIEW

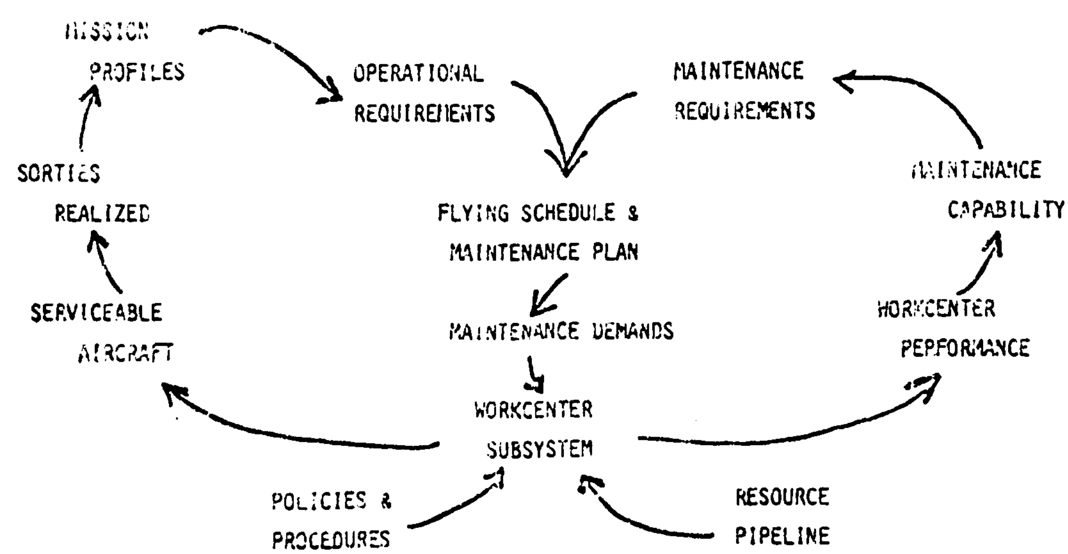


Figure 1

MODELING SKILL LEVEL EFFECTS ON
MAINTENANCE CAPABILITY

Joseph P. Racher, Jr.

Overview

The main goal of an Aircraft maintenance program is to provide the maintenance capability needed to meet mission requirements in a cost effective manner. But what is maintenance capability and when do maintenance managers know when they have achieved the level of capability required? Air Force Regulation 66-14 states that maintenance capability is "the availability of those maintenance resources (facilities, tools, test equipment, drawings, technical publications, trained maintenance personnel, engineering support and spare parts) needed to carry out maintenance." The regulation goes on to state that maintenance capacity, a measure of maintenance capability, is "usually expressed as the amount of direct labor man-hours that can be applied within an industrial shop, or other entity during a 40-hour week." Inherent in these definitions is the recognition that each resource has a set ability level. This ability is the type and amount of work the resource was designed or trained (in the case of people) to perform. If one assumes this ability level is fixed, then maintenance capacity becomes only concerned with the direct production time which can be achieved by a resource. In this case, in order to increase maintenance capability (resource availability), one has to obtain more resources or increase the direct production time of the available resources. In going back to the above question--when has one obtained the required maintenance capability--under the AFR 66-14 framework, this has been done when one has assembled the necessary resources to accomplish the required maintenance actions on a piece of equipment, and has kept these resources up and running as required to meet the workload.

This concept of maintenance capability (along with the assumption of fixed abilities) seems simple. All the maintenance manager has to do is know the defined abilities of the related resources and predict the workload. The manager then acquires the combination of resources and defines the production time that meets the predicted workload. When the manager has the required resources needed to do the job, the necessary maintenance capability (resource availability) has been achieved. However, the assumption that a set of resources, as given in the above definitions, has a fixed set of abilities, is not well founded. This set of resources, in fact, do not possess a constant performance level. The primary reason for this performance variability is the fact that the manpower resource, which is an integral part of maintenance capability synthesis (technicians are the catalyst for producing maintenance out of a set of resources), have varying abilities to perform maintenance. Abilities vary from person to person, depending on the individual's training background and experiences. With this insight, one must add a corollary to the definition of maintenance capability presented earlier. One must consider what the production abilities of the given set of resources are, and how these abilities changeover time. Maintenance capacity will then be concerned with the production output of the group over a period of time. This recognizes that there are other driving factors affecting performance, other than the availability of the resources.

To get this application really moving, we need one ALC to develop the prototype AFLC wartime push system. Ogden would be the logical choice. To do this, we need a World Wide Military Command and Control System (WWMCCS) remote terminal and a Combat Supplies Management System Interface at Ogden. The range of items should be extended to cover all recoverables, EOQ items, and engines. Procedures should be required and published, and at the suggestions of PACAF, conduct a live test. As soon as possible the tool should be extended to other ALCs.

NOTES

1. "H6000 Combat Supplies Management System (CSMS) Increment 2 Functional Specification," Air Force Data System Design Center, 1981.

2. For a description of Dyna-metric, the interested reader is referred to: Hillestad, R. (1982. "Dyna-METRIC: A Mathematical Model for Capability Assessment and Supply Requirements When Demand, Repair and Resupply Are Nonstationary." Santa Monica, CA: The Rand Corporation, R-2785-AF; Pyles, R.A. (1982). "The Dyna-METRIC Readiness Assessment Model: Motivation, Capabilities, and Uses." Santa Monica, CA: The Rand Corporation, R-2886-AF; Pyles, R.A. and Lt. Col R.S. Tripp (1982). "Measuring and Managing Readiness: "The Concept and Design of the Combat Support Capability Management System," Santa Monica, CA: The Rand Corporation, N-1840-AF; and Tripp, Major R.S. and J. Wennefeld (1981), "Improving the Capability of System Managers to Manage Aviation Spares and Component Repair," Santa Monica, CA: The Rand Corporation, WE-1202-AF.

INTENDED USERS AND USES

USERS	USES
SYSTEM MANAGERS MAJCOM LOGISTICS STAFF MAJCOM OPS STAFF HQ AFLC, MAJCOM HQ HQ USAF	DETERMINE ADEQUACY OF PLANS ADVOCATE PLANNED RESOURCE CHANGES STOCK TRANSPORTATION REPAIR ADVOCATE WAR PLAN CHANGES FORCE MIX LOCATION SORTIE REQUIREMENTS LOGISTICS SUPPORT MAINTENANCE FOLLOW-ON SPARES
SYSTEM MANAGERS MAJCOM LOGISTICS/OPS STAFF	DETERMINE ADEQUACY OF ACTUAL FIGHTING UNITS PROVIDE FEEDBACK TO MAJCOMS OBTAIN RESOURCES NEEDED

FIGURE 6

number of FMC aircraft times the appropriate turn rates for those days, and achieve sorties. The line with dashes only indicates the number of sorties we could generate if we had no airplanes down due to spare parts. The line with dots indicates if we didn't have any depot resupply, how many sorties we could generate. The line with dots and dashes shows if we arbitrarily set a 15% NFMC goal how many sorties we could generate. The point here is that these turn rates and the sorties achieved are a function of logistics constraints, as well as how the operators are going to fly them.

NFMC and sortie goals can be higher or lower. If we have higher goals, such as 5% NFMC rates, we will get a larger range and depth of problem parts. If we set them lower, we'll get less range and less depth. We need operations and logistics officers to specify desired goals, and then we need the SM to play an active role to show what the impact of those decisions will be of the total force.

Intended Users and Uses

Figure 6 shows the intended users and uses of this application.

Strengths of Designed Solution

For brevity the major strengths are listed below:

Concentration on major goals - sorties, NFMC rates

Weapon system orientation

Squadron level detail

Item level detail

Transportation - maintenance - supply interactions

Dynamics considered

Improving the Application

There were several limitations in our application. On the AFLC side the range of items we looked at was narrow. We only looked at recoverable items in the WRSK. We didn't coordinate our push plan with munitions push plans. We didn't include engines and we didn't include peacetime levels. Additionally, we did not have continuous updates of force movements.

For this exercise, we established a theatre centralized distribution system at Kadena AB and assumed transportation was available via Military Airlift Command (MAC) channels. However, these two conditions may not be available in all scenarios. In addition, we did not consider expedited shipment of depot items back to the CONUS for repair.

To enhance efforts in this area, we're building a data base with all F-4 combat units so that we can evaluate any scenario on a worldwide basis. Also, we're going to include peacetime stocks, extend the range of items beyond the WRSK, and enhance the procedures.

following rules:

1. Maximum assignment of 3-levels with 5-levels on two man tasks.
2. Qualified 3-levels may be assigned to a task by themselves.
3. If a task requires two people but only one is available, the one will be dispatched and the next technician to become available will be dispatced as the assistant.
4. If the properly skilled resource is not available for a particular task, the other skilled resource will be assigned to the task.

The mechanism used in the model to accomplish these rules is a series of queues associated with two resource allocate nodes (Fig 9). One allocate node represents the 5-level technicians (40) and the other represents the 3-level resource (41). Each queue shows a preference of one resource over the other in order to assign the correct ability level to meet the task's minimum skill requirements. If the required resource is not available, the other allocate node will be checked.

As stated earlier, the workorder transaction is routed first to the appropriate queue based on its attributes. In the case of a two man task, a duplicate transaction is routed to an assistant queue. When the resource is assigned to the transaction, a task time is also given to the transaction as an attribute. This task time is based on the ability level (3 or 5 level) of the resource actually assigned. For two men teams, the actual time assigned is based on the primary team member's skill level. The assumption is made that the primary team member will do most of the work. Note that when the primary team member is assigned from one resource, a nodal modification occurs which routes the duplicate transaction to the assistant queue node which checks the other resource type first (nodes 27 and 28 in Figure 9 are are tied to the acivities 17 and 18 in Figure 10 through the nodal modification routine). The task time of the assistant would be the same as the primary team member's time and both are adjusted for any delays in assignment of the assistant. The workorder transactions, once assigned the resources, are then routed to the task activity. In the case of the two man transaction, the primary and assistant transactions are matched together after going through the allocate nodes (Fig 10) and then passed on to the task activity section of the model.

If no technicians are available at the allocate nodes, the transaction is balked back to the backlog queue (Fig 3, queue node 200) for later resource assignment. If the workorder is a two man task, then a nodal modification occurs when the original transaction is balked and the duplicate transaction is killed (Fig 9, nodes 29, 30 and 37; activities 12--Fig 3--and 16--Fig 9).

<u>Task Activity</u> (Figures 11 and 12)

The task activity begins by scheduling the task activity according to the transaction's task time attribute. At the expiration of the task time, the transaction is completed and the resources are freed. The impacts of the quality of the technicians work is then assessed. These impacts can be two fold. First, the individual may complete the task but on completion discover that some errors were made. In such a case, the transaction will be assigned an indicator at node 95 which will re-route the transaction (Fig 12) back to the backlog queue (Fig 3, node 200) for task reaccomplishment. The second possibility is that the error will go undetected at the time of task completion. This will cause that systems failure rate to increase.

STRUCTURAL MODEL
TASK ACTIVITY

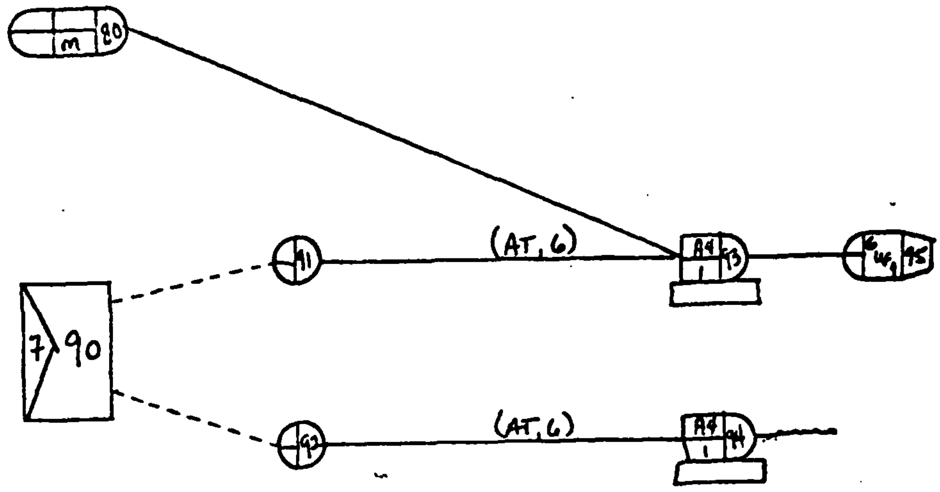


Figure 11

STRUCTURAL MODEL
WORK QUALITY

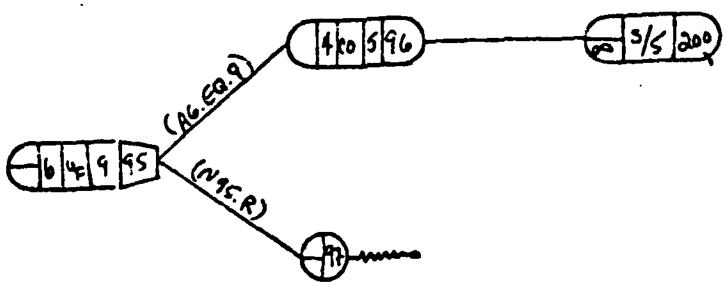


Figure 12

If this occurs, a subroutine is activated at node 95 to adjust the failure rate distribution associated with that system's source node (Fig 3).

Table 1

Input Measurements

- Work order frequency for each aircraft system.

- Task frequency for each system.

- For each task:
  - -- % which are priority 1 workorders.
  - -- % which are priority 2 workorders.
  - -- % which require 5-Level skills.
  - -- % which can allow 3-Level skills.
  - -- % which require 2 technicians.
  - -- % which require only 1 technician.
  - -- 5-Level mean task time and standard deviation.
  - -- 3-Level mean task time and standard deviation.
  - -- Training task time and standard deviation.
  - -- Workload threshhold for not conducting training.
  - -- Should task be included in the training program?
  - -- Average training repititions required for 3-Level qualification and standard deviation.
  - -- Probability that an error will occur.
  - -- Probability that the error will be detected upon task completion.
  - -- How work quality affects the system failure rate.

Summary

This concludes the description of the workcenter structural model. In summary, Table 1 brings together the type and detail of the information required to computerize and run this simulation model. Table 2 shows the type of information which can be obtained from such simulations.

The first three output statistics listed in Table 2, are essential for the maintenance capability scenarios discussed at the beginning of this paper. The maintenance manager must ensure these performance times are in line with the required maintenance capability needed to meet the mission. In other words, maintenance must make sure they can handle the workload generated by the mission. The other output statistics provide insight into hos the on-the-job training program is impacting these performance times.

Finally, the end answer to the question of how the manpower issues affect the maintenance capability of a workcenter, can only be obtained by looking at the problem at the level of detail covered in this paper, and by understanding the decision processes used at the workcenter management level.

Table 2

Output Statistics

- Average work order backlog time
- Average task time
- Average workorder through-time
- 5-Level utilization rate
- 3-Level utilization rate
- Time utilized for training
- Statistics on the number of training events
- Statistics on 5-Levels performing 3-Level work
- Statistics on 3-Levels performing 5-Level work
- Statistics on task reaccomplishments do to poor quality of work

AWARES

Assessment of the Wholesale and Retail System

Presented by

James H. Bigelow

The Rand Corporation

Only the preface and summary are included here:

For more detailed information,
contact the author at:

(213) 393-0411

Copy No ____________

Contract No ____________

Special Instructions ____________

WORKING DRAFT

AWARES

ASSESSMENT OF THE WHOLESALE AND RETAIL SYSTEM

James H. Bigelow

March 1982

WD-1459-MRA&L

Prepared For

Office of the Secretary of Defense,
Manpower, Reserve Affairs, and Logistics

Rand
SANTA MONICA, CA 90406

PREFACE

This Working Draft documents a briefing presented by the author at the 1982 USAF Logistics Capability Assessment Symposium held at the Air Force Academy in Colorado Springs in March. The briefing reports on work currently in progress--research sponsored by the Office of the Secretary of Defense, Manpower, Reserve Affairs and Logistics, under contract No. MDA 903-81-C-0381. This and a companion paper, WD-1468-MRA&L "Depot Extensions to Dyna-METRIC," together constitute a report of the work accomplished under the contract cited above, during the period from 1 June, 1981 to 1 April, 1982.

SUMMARY

AWARES (Assessment of the Wholesale And REtail System) is a model currently being developed at Rand under the sponsorship of OSD (MRA&L). Its purpose is to relate support system resources, especially resources of the wholesale part of the system, to the performance of the operational air forces during dynamic (wartime and peacetime) scenarios.

The resources considered are those relevant to recoverable aircraft components, including spares, transportation, and the resources needed for repair. The support system that uses these resources is divided into several functional areas (supply, maintenance, transportation) and echelons (flight line, base-level supply and maintenance, wholesale supply and depot- level repair). AWARES represents the various functional areas and echelons as a network of stockpiles and pipelines filled with spare components, through which components move at rates dependent on transportation and repair resources.

One potential application of AWARES is to trade off different kinds of resources to determine "balanced" support packages. Currently, resource requirements are calculated separately by functional area and echelon, which can result in some areas receiving more resources than needed, and other areas less. Another application concerns assessing the capability of depot level maintenance to support the operating forces in wartime, and to maintain readiness in peacetime. For example, which weapon systems are affected by depot resource limitations, and what (if any) measures can be taken at the depot to ameliorate the effects of the limitations?

So that AWARES can be applied in these ways, we are building it to have the following properties. First, it will consider the worldwide air forces, including all bases and all MDS's. Second, it will calculate not only the resources needed to support a given scenario; it will calculate diagnostics as well, to guide the user in restructuring the support package to support the same scenario, or to modify the scenario so the required resources will not exceed available resources.

A prototype version of AWARES exists and is installed at the Ogden ALC. The flight line, base-level supply and maintenance, and transportation are modeled fairly completely in the prototype, but the representation of the wholesale echelon is rudimentary. Jointly with the Readiness Initiatives Group at Ogden, headed by Lt. Col. R. Tripp, we are testing the prototype with data from the Ogden landing gear facility. It is too soon to comment on results of this ongoing test.

THE GEORGE WASHINGTON UNIVERSITY
School of Engineering and Applied Science
Institute for Management Science and Engineering

Program in Logistics

MARINE CORPS READINESS EVALUATIONS

A SUMMARY FOR LOGCAS 82

by

Zeev Barzily
W. E. Caves
W. H. Marlow
Lt. Col. Ronald K. Roth, USMC
Lt. Col. Samuel D. Turner Jr., USMC
S. Zacks

Serial 72445
12 March 1982

A major difficulty in measuring the readiness of a military unit is the fact that it cannot be done under actual combat conditions. It must be evaluated instead through exercises consisting of typical operations it is supposed to be able to execute. And more than this, it is generally necessary to evaluate in terms of "How closely did execution conform to doctrine?" rather than directly in terms of "Can the unit do its job?" This is true because it is generally simpler to decide how successful an operation was, and what were the strong and weak points of execution, than it is to decide exactly why a unit performed as it did, and what this foretells for its many required capabilities.

The Marine Corps Combat Readiness Evaluation System (MCCRES) uses simulated combat to evaluate the readiness of Marine units. Specific tests have been designed to evaluate infantry units, rotary wing and observation squadrons, fixed wing squadrons, combat support elements, combat service support elements, and so on, covering all units in the Corps.

Our work is based on categorization schemes which identify fundamental activities required for any unit to be able to do its job and consequently to be ready for combat. We find that MCCRES data--especially when they are supplemented by the new evaluation measures we advocate--are ideally suited for helping experienced commanders evaluate readiness and plan training programs. These new measures help explain why units performed the way they did, and what specific remedial training actions are called for. These new measures are also useful in a number of other applications such as identifying trends in readiness, designing evaluations subject to constraints, and so forth.

Two specific approaches to categorization are to be presented at LOGCAS 82. Technical reports are expected to be available by summer 1982. The reference presents the original scheme and its uses for infantry evaluations.

REFERENCE

Barzily, Z., P. R. Catalogne, and W. H. Marlow (1981). Assessing Marine Corps readiness. Defense Management Journal, Vol. 17 No. 1 pp 25-29.

FORECASTING WARTIME RESOURCE REQUIREMENTS

COLONEL DONALD C. TETMEYER
LOGISTICS & TECHNICAL TRAINING DIVISION
AIR FORCE HUMAN RESOURCES LABORATORY (AFHRL)

VU-GRAPH 1

AFHRL's interest in this area started with our original work with LCOM in the early 1970s. At that time we were using the simulation to relate A-10 design issues and manpower needs to combat sortie capability. As part of this effort, we tracked failure rates and resource demands of A-7s operating in SEA and compared them with A-7s based at various locations in the states. We found significant differences in the distribution of failures between SEA and CONUS, and between CONUS bases in different climates. For example, maintenance rates for the bombing radar were 3 to 4 times greater in SEA, and there was significant maintenance on ECM, RHAW, and IFF systems that didn't show up stateside. Within the CONUS, far more corrosion related maintenance was recorded in the salt air of Myrtle Beach than in the desert climate of Davis-Monthan.

At that time we concluded that our ability to model maintenance phenomena far exceeded our confidence in the input data available to feed the models we were creating. I still hold that opinion today. In addition to LCOM the Air Force now has dynametric, the AFLC effort on WARS, TSAR with its theatre simulation capabilities, and many more. However, all still share the same lack of valid input data for wartime conditions.

VU-GRAPH #2

This normalized comparison of F-4 downtime per sortie shows how the proportions of maintenance work differed between SEA operations and CONUS. A further breakdown would show differences in the distribution of sub-systems contributing to the unscheduled downtime.

VU-GRAPH #3

In recent years a lot has been said about "linearity": whether maintenance demand rates are directly proportional to flying hours, or whether they change with utilization. That may be an important issue for the overall peacetime spares budget, but I don't believe it is the most productive way to assess requirements for different combat environments. We should be looking for the underlying drivers - the rates that can be used across all environments. For example, if we find gun failures are fundamentally related to rounds fired, we can assess the expected gun usage for different scenarios and more accurately project maintenance needs. To use this approach, each class of sub-system needs to be examined separately.

VU-GRAPH #4

Mission frequency and length in combat operations are often quite different from peacetime. As a first cut, we need to know the extent to which sub-system failures are driven by cycling or operation during a particular mission segment, rather than uniform with flying time. When Larry Howell was at ASD he tracked cargo aircraft missions and maintenance by tail number to come up with such an analysis for each type of subsystem. This example of linear regressions from his work shows that the cycling effect (sorties) is a dominant driver of C-130 engine failures. The C-141 engines show a stronger flying time relationship.

VU-GRAPH #5

Boeing has analyzed the maintenance data from B-52D combat missions flown out of 3 different bases, and compared it to CONUS experience. A high rate of short (4-hour) sorties was flown from U-Tapao, while fewer but much longer (12-hour) sorties were flown out of Andersen on Guam. Kadena flew 8-hour missions which correspond to the average CONUS peacetime mission. Two patterns emerge. The hydraulic power system is representative of a large class of equipment that has similar removal rates in peacetime (CONUS) and combat (Kadena), but shows a distinct sortie effect. The weapons delivery sub-system data shows the significant impact of combat usage as well. Some other driver, such as weapons delivered, is needed to predict maintenance requirements on this system.

VU-GRAPH #6

Frank Maher at AFHRL has been working on combat resource requirements assessment for several years, through contracts with Carl Asiala at McDonnell-Douglas and George Herrold's Experience Analysis Center at Boeing. McDonnell-Douglas initially quantified the sensitivity of F-15 sortie generation to different mixes of manpower, spares and support equipment. These simulations were based on peacetime and surge exercise data. We then sought battle damage incident and repair data for high intensity war through visits to the Israeli Air Force. Some of you may have attended our briefing on the Israeli experience, which has been presented to General Minter. A classified report is in printing. We have also contracted with Boeing for an extensive analysis of maintenance rates, covering a wide spectrum of aircraft and bases, to identify significant environmental drivers of sub-system maintenance. For example, we have found hydraulic leaks related to temperature variations, certain avionics failures related to wet climates, and weather radar maintenance related to thunderstorm activity. The initial investigation was statistical. Boeing is now analyzing the causative factors, and I expect full results will be published by the end of the year. Most of this work has been with peacetime data. We are now conducting an extensive survey to locate sources of wartime maintenance data. We will then integrate all of this information to identify the driving relationships for predicting combat maintenance demands. It will also aid our work in developing training and proficiency assessment methods for combat maintenance tasks. I'm here today to report our progress in finding sources of combat data.

VU-GRAPH #7

Data on maintenance of US built aircraft in combat is potentially available from two recent wars. The Yom-Kippur war is of particular interest because of the high threat level and intensity. Through contract with Clemson University, Lockheed and McDonnell-Douglas we are locating data sources, developing a standard data structure, determining what it would take to actually put data into this structure, and then looking at how it might be maintained and made accessible to AF analysts on a continuing basis.

VU-GRAPH #8

The National Archives has operational data on SEA combat missions and sorties. The OPREA file contains mission data. The others include over 50 data tapes with more detail on individual sorties. There are holes in the detail, but the overall coverage is probably the best that exists. The Center for Naval Analyses and Simpson Historical Center are good sources of reports,

analyses, and lessons-learned, but not raw maintenance data. I'll talk more about these in a moment. Naval Air Systems Command has some 3M data and several of the aircraft manufacturers have saved Air Force MDC data covering combat maintenance in SEA.

VU-GRAPH #9

The Air Force Flight Dynamics Laboratory operates the Combat Data Information Center under sponsorship of the Joint Technical Coordinating Group for Aircraft Survivability and Munitions Effectiveness. It includes extensive information on damage and loss incidents and survivability analyses, but not on other maintenance.

VU-GRAPH #10

The Air University collection includes over a quarter million narrative reports and analyses on SEA experience. The information is grouped by different phases of the war. This background on the nature of operations, and the equipment that was critical for the kind of missions flown in each phase, is important for understanding differences in wartime maintenance rates. The Simpson Center also has reports of the initial US teams to visit Israel after the Yom-Kippur war, and a breakout of the 22,000 tons of US parts and supplies that were airlifted in.

VU-GRAPH #11

Boeing's Experience Analysis Center is by far the most comprehensive source of MDC data from SEA. Much of it has been converted to the current 9 track format. With these data, the operational data from the National Archives, and the background and context provided in reports from the Air University Library, we believe that we have found the information necessary to proceed.

VU-GRAPH #12

The Yom-Kippur war was a high intensity air combat environment to complement our information from SEA. Our discussions with the Israelis confirmed that their wartime and peacetime spares usage was significantly

different for some critical sub-sysyems. They indicate about 2% of the items caused most of the problems. We have not yet been given access to their quantitative data, but plan another visit later this year. A look at what we had to airlift during their war shows that engines, weapons delivery sub-systems, tires, structural parts for battle damage repair, and TRAP were the likely problem areas.

CONCLUSION:

By the end of the year we will have reviewed all the data sources and established a data bank architecture. We are working with the Flight Dynamics Laboratory to see is their Combat Data Information Center can be expanded into an accessible permanent repository for all quantitative wartime operational and maintenance data. By this time next year, I hope to report on our progress in using these data to analyze the wartime maintenance drivers.

REFERENCES

B-52D Operations in Southeast Asis vs CONUS, Boeing Military Airplane Systems Division, September 1970

Capt Lawrence O. Howell, A Method for Adjusting Maintenance Forecasts to Account for Planned Aircraft Sortie Lengths, ASD-TR-78-26, August 1978.

PREFACE

This report describes a briefing presented by the author at the 1982 USAF Logistics Capability Assessment Symposium held at the Air Force Academy in Colorado Springs in March. The research was performed in the Resource Management Program under the Project AIR FORCE project "The Driving Inputs and Assumptions of Stockage/Assessment Models."

Copy No. ____________

Contract No. F49620-82-C-0018

Special Instructions ____________

WORKING DRAFT

ASSESSING AND IMPROVING THE FORECASTING ATTRIBUTES OF DYNA-METRIC: AN F-16 CASE STUDY

Major Jon R. Thomas

March 1982

WD-1457-AF

Prepared For

United States Air Force

Rand
SANTA MONICA, CA 90406

Form 578 (Rev. 10/80)

ISRAELI AIR FORCE

- SPARES CONSUMPTION RATES -1973 CONFLICT DATA
  - PILOT DECREMENTS LESS
  - PEOPLE ARE MORE DETERMINED
  - DISTRIBUTION OF FAILURES DIFFERENT
- 2% OF PARTS CRITICAL
  - HIGHER DEMANDS ON ENGINE, WEAPONS DELIVERY. TIRES
  - BATTLE DAMAGE
  - TRAP
- REMOVE AND REPLACE QUICK TURN
  - HIGH PERCENTAGE OF NO FAILURES

BOEING EXPERIENCE ANALYSIS CENTER

- COMBAT AND PEACETIME MDC DATA ON:

A7D	F4D
B52D	F4E
C123	RF4C
C130	F105
C135	F111
C141	

- ON TAPE IN CONVERTED 9-TRACK FORMAT

COMBAT INFORMATION CENTER

- SPONSORED BY JOINT TECHNICAL COORDINATING GROUPS FOR AIRCRAFT SURVIVABILITY AND MUNITIONS EFFECTIVENESS

- COMPUTERIZED DATA BASES
  - ACFTDAB (11,000 SEA INCIDENTS)
  - HELODAB (18,000 SEA INCIDENTS)
  - ARMY BDARP (700 GROUND VEHICLE SEA INCIDENTS)
  - YOM KIPPUR DATA BASE (774 TANKS AND APC'S)
  - RAM TEAM DATA BASE (793 SEA INCIDENTS)
  - LASER DAB (LASER TEST DATA BASE)
  - AIRCRAFT COMPONENT TEST DATA BASES

- REFERENCE LIBRARY DATA BASES
  - 3000 HARD COPY REPORTS

ALBERT F. SIMPSON
HISTORICAL RESEARCH CENTER

- **CORONA HARVEST PROJECT (1954-1970)**
  - 1800 SEA LESSONS LEARNED (111 KEY LOGISTICS LESSONS)
  - AIRPOWER EFFECTIVENESS MEASUREMENT
  - DATA BASE INVENTORY/KEY WORD OUT OF CONTEXT SYSTEM (263, 746 DOCUMENTS)
  - I-IV TIME PERIODS
- **PROJECT CHECO REPORTS**
  - HQ PACIFIC AIR FORCES (PACAF)
  - AERIAL OPERATIONS IN SEA
  - 218 PUBLISHED REPORTS
- **ARAB/ISRAELI CONFLICTS**
  - OPERATION NICKEL GRASS
  - U.S. MILITARY EQUIPMENT VALIDATION TEAM
  - MAJOR GENERAL BENJAMIN PELED, COMMANDER IAF, COMMENTS
  - 352 REFERENCES

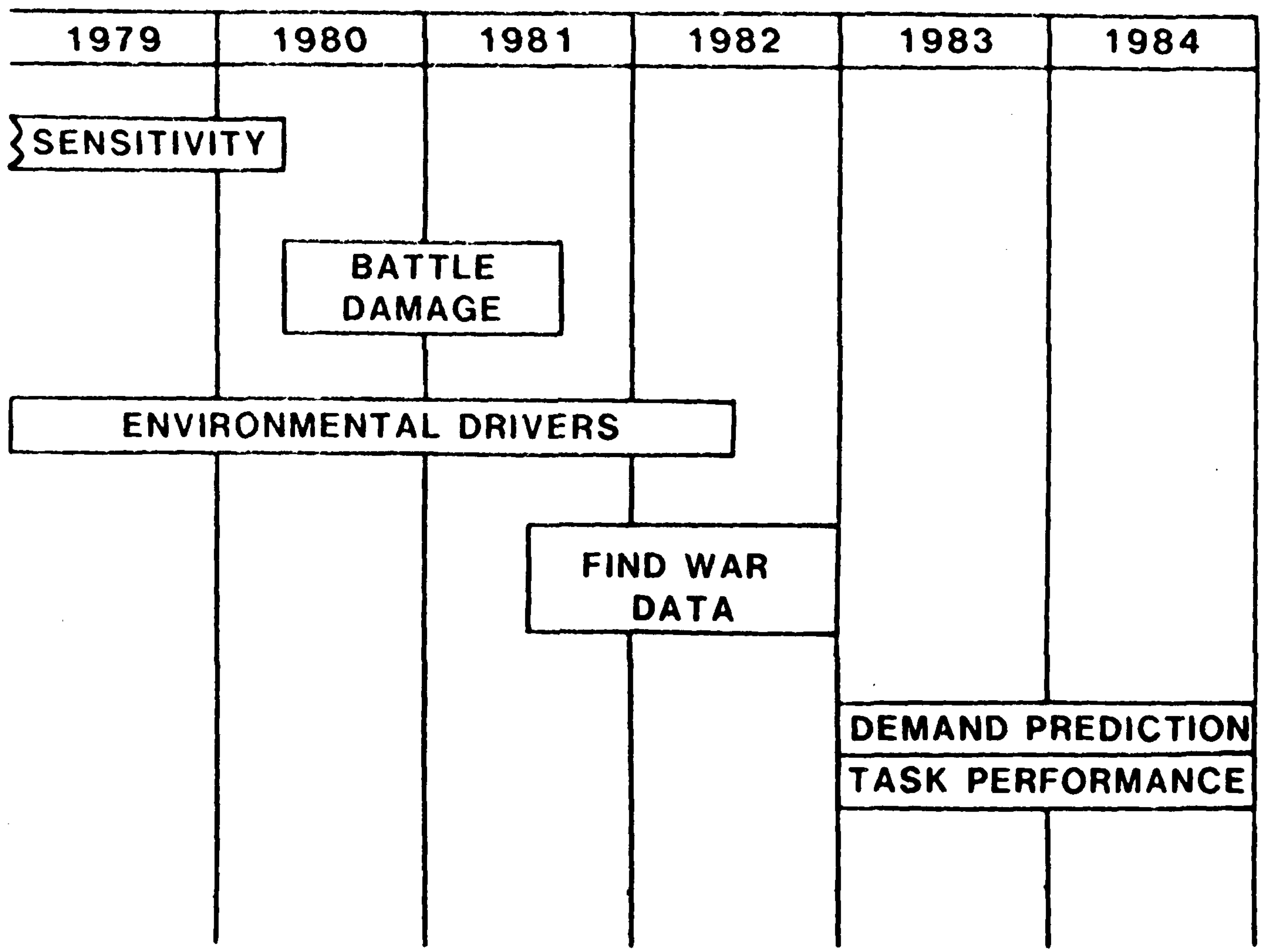
SOUTHEAST ASIA DATA SOURCES

- NATIONAL ARCHIVES AND RECORD SERVICE
  - COMBAT AIR SUMMARY FILE (OPREA)
  - COMBAT ACTIVITIES FILE (CACTA) 1965-1970
  - SOUTHEAST ASIA DATA BASE (SEADAB) 1970-1975
- CENTER FOR NAVAL ANALYSES
- COMBAT DATA INFORMATION CENTER
- ALBERT F. SIMPSON HISTORICAL RESEARCH CENTER, MAXWELL AFB
- NAVAL AIR SYSTEMS COMMAND
- AIRCRAFT AND EQUIPMENT MANUFACTURERS
  - MCDONNELL AIRCRAFT COMPANY
  - DOUGLAS AIRCRAFT COMPANY
  - BOEING AEROSPACE COMPANY
  - VOUGHT CORPORATION
  - GENERAL DYNAMICS CORPORATION
  - ROCKWELL INTERNATIONAL
  - NORTHRUP
  - GRUMMAN AIRCRAFT COMPANY

LOCATING DATA SOURCES

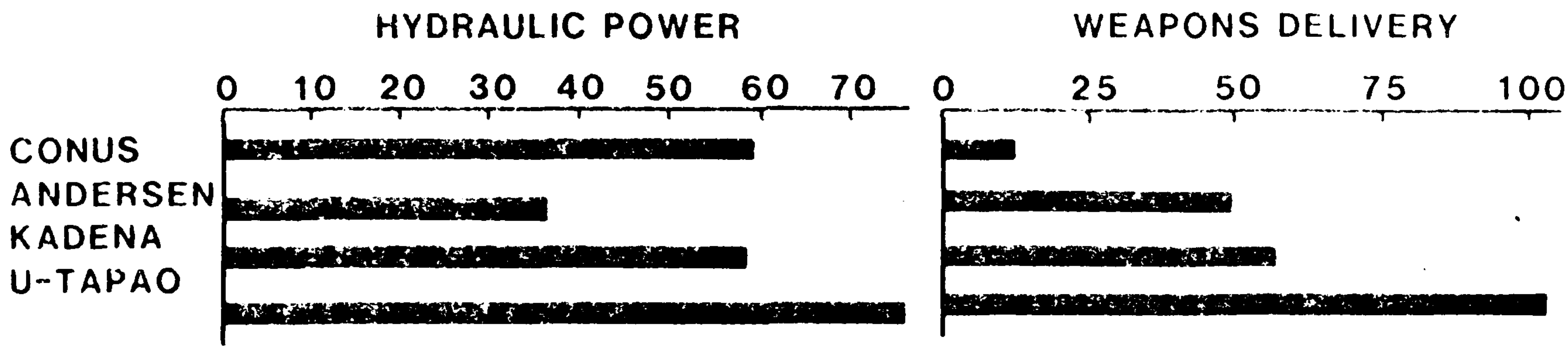
- TWO WARS
  - SOUTHEAST ASIA
  - ARAB ISRAELI
- DEVELOP COMBAT DATA BASE ARCHITECTURE
- DETERMINE RETRIEVAL TRANSFORMATION SOFTWARE REQUIREMENTS AND COSTS
- ARRANGE FOR ACCESSIBLE REPOSITORY

AFHRL WORK ON FORECASTING MAINTENANCE RESOURCE DEMANDS IN COMBAT



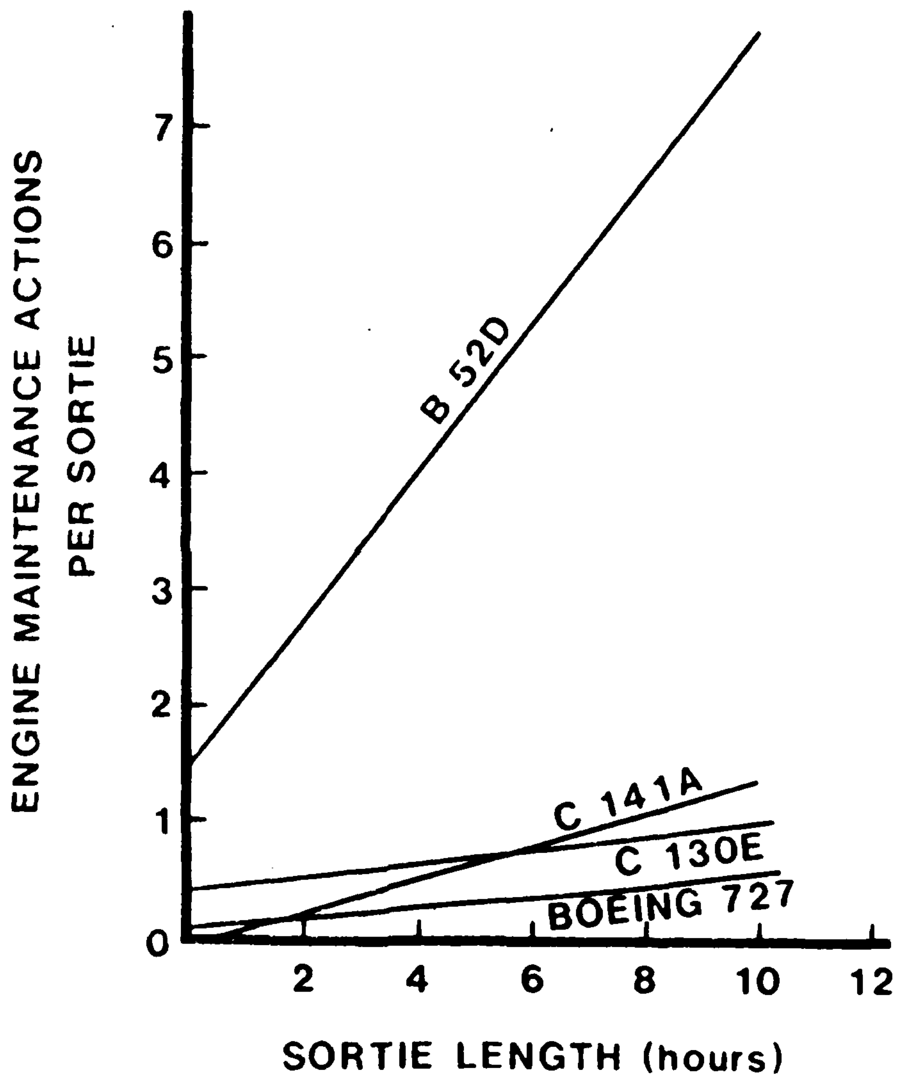
DIFFERENT DEMAND DISTRIBUTIONS

REMOVALS PER 1,000 FLIGHT-HOURS



SOURCE: BOEING CO., 1970

SORTIES OR FLYING HOURS?



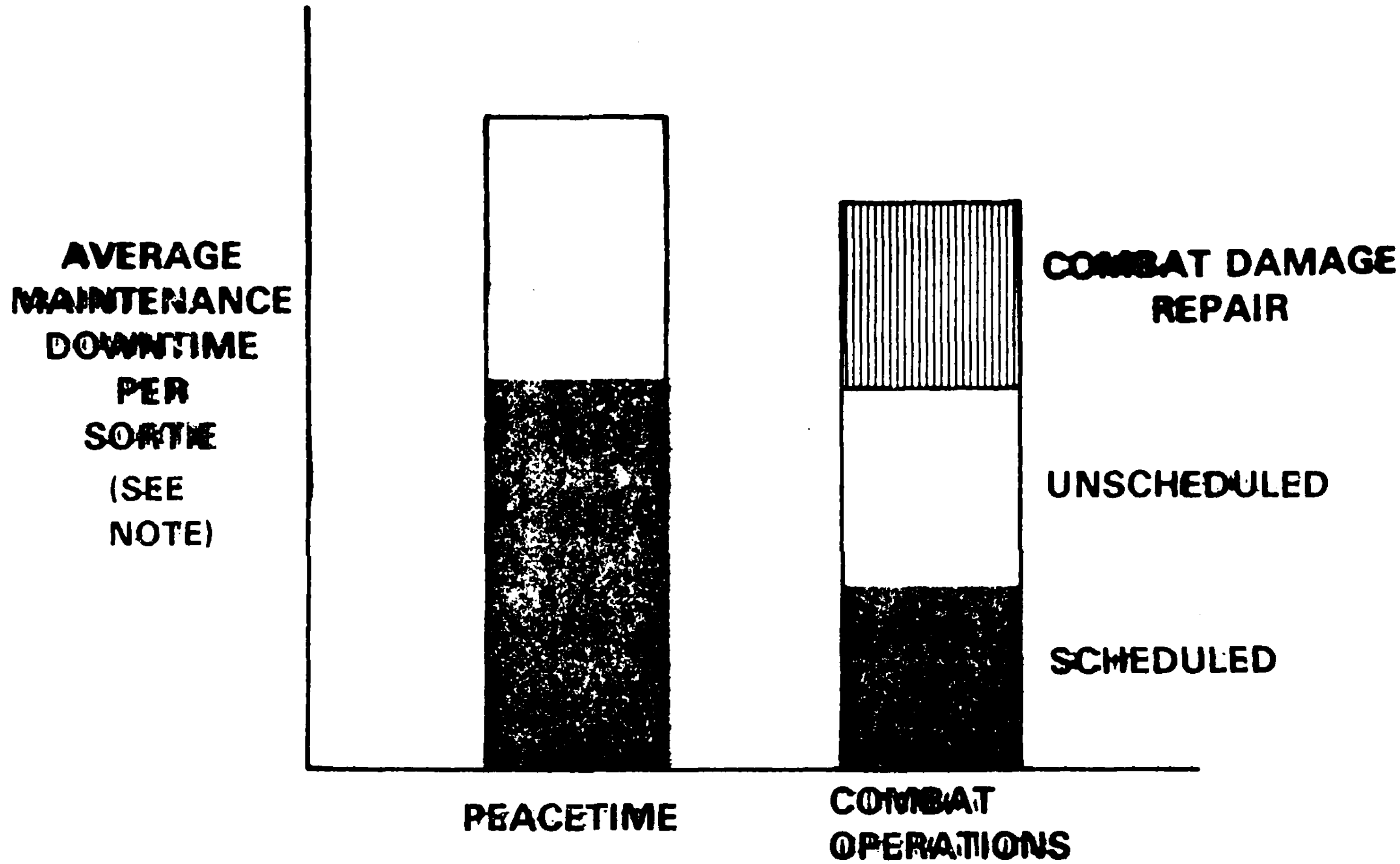
SOURCE: HOWELL (ASD) 1978

PHILOSOPHY/APPROACH

- MATHEMATICAL FORM ("LINEARITY") IS NOT THE KEY ISSUE
- NEED TO IDENTIFY THE VARIABLES AND MECHANISMS THAT DRIVE FAILURES
- BASE PREDICTIONS ON VARIABLES THAT GIVE INVARIANT ("LINEAR") DEMAND RATES IN PEACE AND WAR

COMBAT OPERATIONS REQUIRE SEPARATE ANALYSES

PD82-513



NOTE: ALTHOUGH THIS FIGURE IS NONDIMENSIONAL, THE GENERAL RELATIONSHIPS OF SCHEDULED, UNSCHEDULED, AND COMBAT DAMAGE REPAIR ARE REALISTIC. ACTUAL VALUES IN HOURS VARY AS A FUNCTION OF SORTIE RATE AND AIRCRAFT TYPE.

MCDONNELL DOUGLAS CORPORATION
Saint Louis, Missouri 63166

AFHRL'S VIEW OF THE PROBLEM

- ADEQUATE MODELS EXIST AND ARE UNDER DEVELOPMENT (LCOM, WARS, ETC .)
- INADEQUATE DATA/METHODOLOGY TO GENERATE MODEL INPUTS FOR COMBAT CONDITIONS:
    - MAINTENANCE AND PARTS DEMANDS
    - PEOPLE CAPABILITIES
    - WARTIME OPERATING PROCEDURES

ASSESSING AND IMPROVING THE FORECASTING ATTRIBUTES OF DYNA-METRIC: AN F-16 CASE STUDY

Major Jon R. Thomas
The Rand Corporation
March 1982

In recent years, considerable progress has been made in the development of technology which translates information regarding resource levels into statements of operational capability. The LCOM, Dyna-METRIC, TSAR, and WARS models are good examples of the innovations that have been made in this area. Because the Air Force is committed to LOGCAS, I believe even greater innovations will be made in the future. However, the challenge we must come to grips with is how to exploit that technology in order to receive the maximum benefits offered by the potential the models provide. In other words, how do we insure successful transition from a research model to an effective management system? At this time, the Logistics Management Center and the Data System Design Center are jointly involved in such a project: the embedding of Dyna-METRIC within the Combat Support Management System (CSMS). I am sure they can attest to the difficulty of the task. Ultimately, what criterion will be used to determine whether we have successfully met this challenge? I can think of only one: has the newly developed system significantly enhanced the decision process? If not, why waste the money to exercise the system? I believe we would have far fewer systems in operation today if, in the design phase, someone had asked this question. To avoid replication, I suggest we seriously consider how we want our LOGCAS models to impact on the decision process, then test their use, under controlled conditions, to determine whether the models truly enhance the decisions to be made. I know this sounds like a "motherhood" statement, but I believe we should be doing more of this thinking in our LOGCAS planning and development efforts.

The remainder of this paper will deal with my attempts to incorporate that philosophy in an assessment of the F-16 System Manager's use of Dyna-METRIC at the Ogden Air Logistics Center. I must point out that this assessment is not complete--data collection is scheduled to continue into the summer. However, there are enough preliminary results to illustrate my approach, which, I believe, is a very rigorous

test of the model. I will also highlight some of the data problems we have encountered and the approach taken to work around them.

The first objective of the study is to improve our understanding of the strengths and weaknesses of the System Manager's use of Dyna-METRIC and associated data bases to make his quarterly projection assessment and his biweekly WRSK assessments. For the quarterly projection assessment, Ogden collects D041 and D104 Stock Balance and Consumption tapes from each of the ALCs and inputs these into their preprocessor, which collects and formats the data needed for Dyna-METRIC. The model is then run from the current time period out thirty months to determine critical shortages. One perceived problem with this approach is that the data are five or more months old by the time the model is run. This perception may or may not be accurate, but the model has not been exercised over a long enough period to instill confidence in the information provided. For the WRSK assessments, they input specially transmitted TAC asset data with files built from the D029 to run the model. Results from these assessments are briefed up the Material Management chain and, at times, to the Center Commander. To date, the major decision impact of these has been on the spending of supplemental procurement funds.

Once we understand the limitations of the model, we will be in a better position to recommend areas for further research, the second objective. When completed, this work may lead to refinements in the model. Of course, the ultimate objective of this process is to increase the System Manager's confidence in the use of the model. To that end, our study is an attempt to learn more about the nature and behavior of dynamic pipelines. We believe that is the most critical test of the model, because all calculations are based on what the model forecasts as the expected number of assets tied up in the various segments of the pipeline. If it can be demonstrated that the model predicts pipeline assets reasonably well, there are few, if any, applications where the model cannot be used with confidence. Furthermore, we must understand the conditions, if any, that cause the model to provide misleading information before we can permit the model to become part of the decision process. Clearly, such understanding is useful not only to Dyna-METRIC, but to other inventory models.

To achieve our study objectives, there are a number of issues or questions which must be addressed. First: Are the best data available being used to exercise the model? Second: Given the correct data, does the model provide reasonable and realistic results? Notice that best data may not always be correct data. The distinction is that there are many applications where the "correctness" of the data cannot be measured or, at best, can only be given as a wide confidence interval. An Equipment Specialist's estimate of an item's demand rate three years into the future, when there are a number of pending engineering change proposals, serves as a good example. Although there is a great deal of uncertainty associated with the Equipment Specialist's estimate, it still may be the best data to use to forecast support requirements three years into the future. However, if we have greater confidence in the model, we are in a better position to assess the impact of this uncertainty by using the model to perform sensitivity analysis around the item's demand rate. It is an unwieldy task to perform sensitivity analysis for all items that are used on a weapon system, but the model may also be used to identify a limited range of items which require further analysis. Alternatively, components' "variance to mean" ratios could be adjusted upward to reflect uncertainty in their demand rate estimates. The joint increased uncertainties would be reflected in the available aircraft output measures.

The third issue is a restatement of a comment made earlier: Does the systematic application of the model enhance the decision process? I believe this is the overriding question that needs to be addressed. It drives the requirements for data. Clearly the quality of the data needed by the model to justify redistribution of assets in support of a wartime push system is much greater than that needed to justify WRM procurement with OMB or Congress. In that context, validation can only be performed with the application in mind, and validation involves not only the model but also the data used for that application.

Our experimental design has two phases: data validation and model validation. In the first phase, we want to determine the accuracy of the D041 data used by the System Manager in his assessments. For that, we will use the factor review files generated each quarter by the Item Manager and Equipment Specialist in support of the D041. The factor

review files contain two years of historical data, by quarter, of the demand and Not Reparable This Station (NRTS) rates for each recoverable item. The current twelve- and twenty-four-month averages for these parameters are maintained along with forecasts of values for the first, second, and third procurement years. (The first procurement year begins at the start of the next fiscal year.) Additionally, the last value used in D041 is also shown. For each quarter, we will compare the last used value with the actual experienced rates. The twelve-month average and the first year forecast values from the preceeding quarter's factor review files will also be compared with the actuals to determine which estimate, if any, is most representative of demand and NRTS actions experienced in the quarter. It may turn out that none of these parameters is particularly robust for forecasting the next quarter's value. In that case, we will conduct regression analyses to determine whether a linear average of the available data provides a better estimate.

In the second phase, we have selected five items for detailed analysis. For these, we are interrogating the Air Force Recoverable Assembly Management System (AFRAMS) each week on a randomly chosen day to develop a sample for the pipelines. We began this sampling in February and will continue through June 1982. Once the March and June 1982 D041 factor review tapes are available, we will run Dyna-METRIC Extended with these data and compare the model's predicted pipelines with those from the AFRAMS sample. Statistical tests will be made to determine whether the differences can be attributed to random variation or to other factors not considered by the model. Because Dyna-METRIC Extended is being used for this aspect of the analysis, we should get a good comparison of how well the model predicts the flow of reparables through both the wholesale and retail systems. Furthermore, we will compare the model's predicted not-fully-mission-capable rates with NMCS/PMCS rates experienced during the two quarters. The model's prediction for not-fully-mission-capable rate is not consistent with the values being measured in the field. However, one would expect the model's rate to be bounded below by the sum of the NMCS and PMCS rates and bounded above by 1-FMC rate. This comparison will test that hypothesis.

The five items selected for detailed analysis are the fire control radar antenna, the fire control radar transmitter, the inertial navigation

unit, the heads-up display electronic unit, and the angle of attack transmitter. These are the items for which we are collecting AFRAMS data. The first four items were selected because they all had been identified as problem items in the System Manager's WRSK assessment. The angle of attack transmitter was selected because, of all F-16 Ogden-managed items, it was the top MICAP item for November 1981; however, it has never been flagged as a problem item in either the quarterly projection assessment or the WRSK assessment. We believe that these items will provide a difficult test for the model; perhaps too difficult, because they are problem items and the system may be doing things that could distort the normal pipeline. We are considering randomly selecting more items for AFRAMS sampling. We think this will give us a better picture of the behavior of a normal pipeline. However, we will continue our analysis of the original five items as we believe there is a lot to be learned from their pipelines, even if atypical.

Figure 1 illustrates some of the data problems we encounter when working with the F-16. The chart reflects the actual demand rate experienced for the fire control radar antenna for each quarter over a one-year period. The actual demand rate is normalized by the average demand rate for the entire year. The figure reflects that, in the quarter ending in September 1981, the demand rate for the antenna was over twice the yearly average. It also reflects a growth in failure rate over the year, which, in fact, is what has happened. Insulation has worn from cables and has required replacement. The D041 estimate of demand rate is also shown. The number plotted at the September 1981 point is the number used in the June 1981 computation to forecast the demands that occur in the July through September quarter. All in all, the Equipment Specialist did a good job projecting the failure rate growth for the item.

Figure 2 shows the same information for the radar transmitter. Again, the data imply failure rate growth; however, in this case, it is not clear whether the last quarter's demand was due to growth or random variation.

Table 1 illustrates the type of comparisons that can be made between model predictions and AFRAMS data. Since there is a good chance

TWELVE-MONTH DEMAND HISTORY FIRE CONTROL RADAR ANTENNA

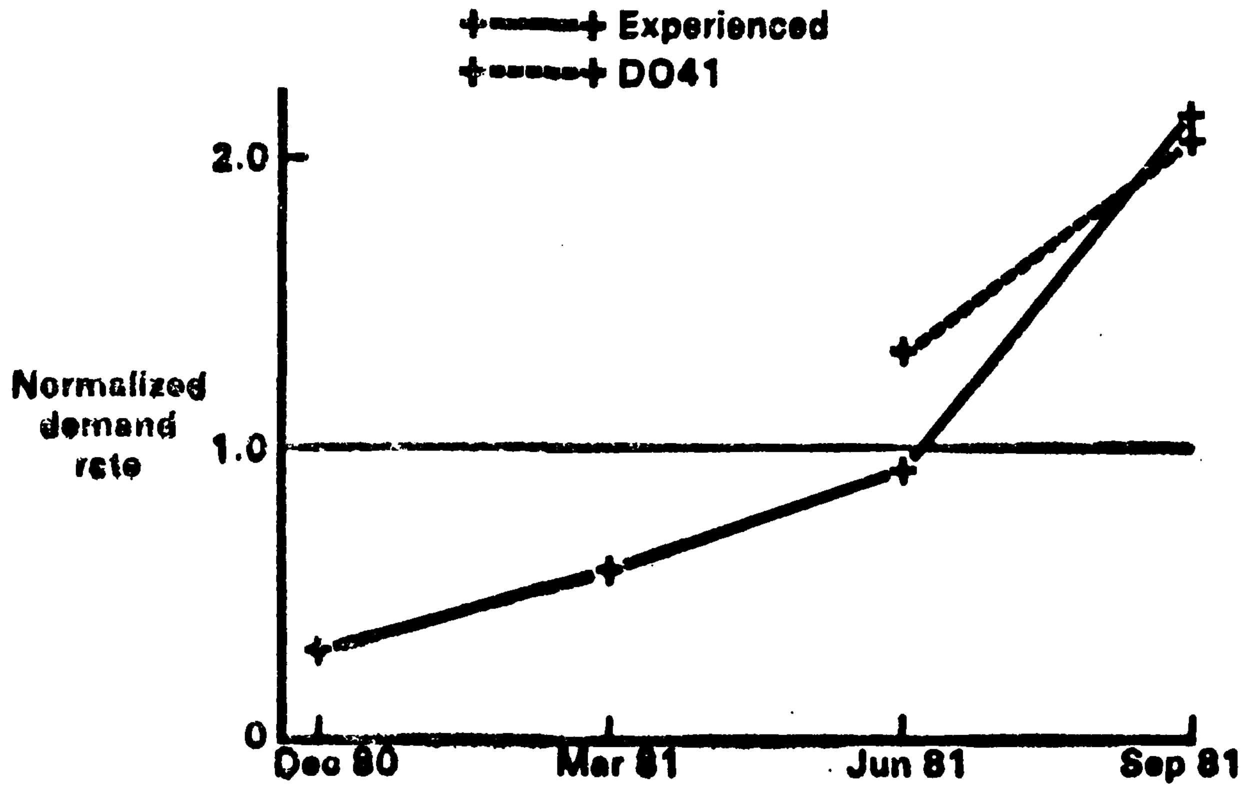


Figure 1

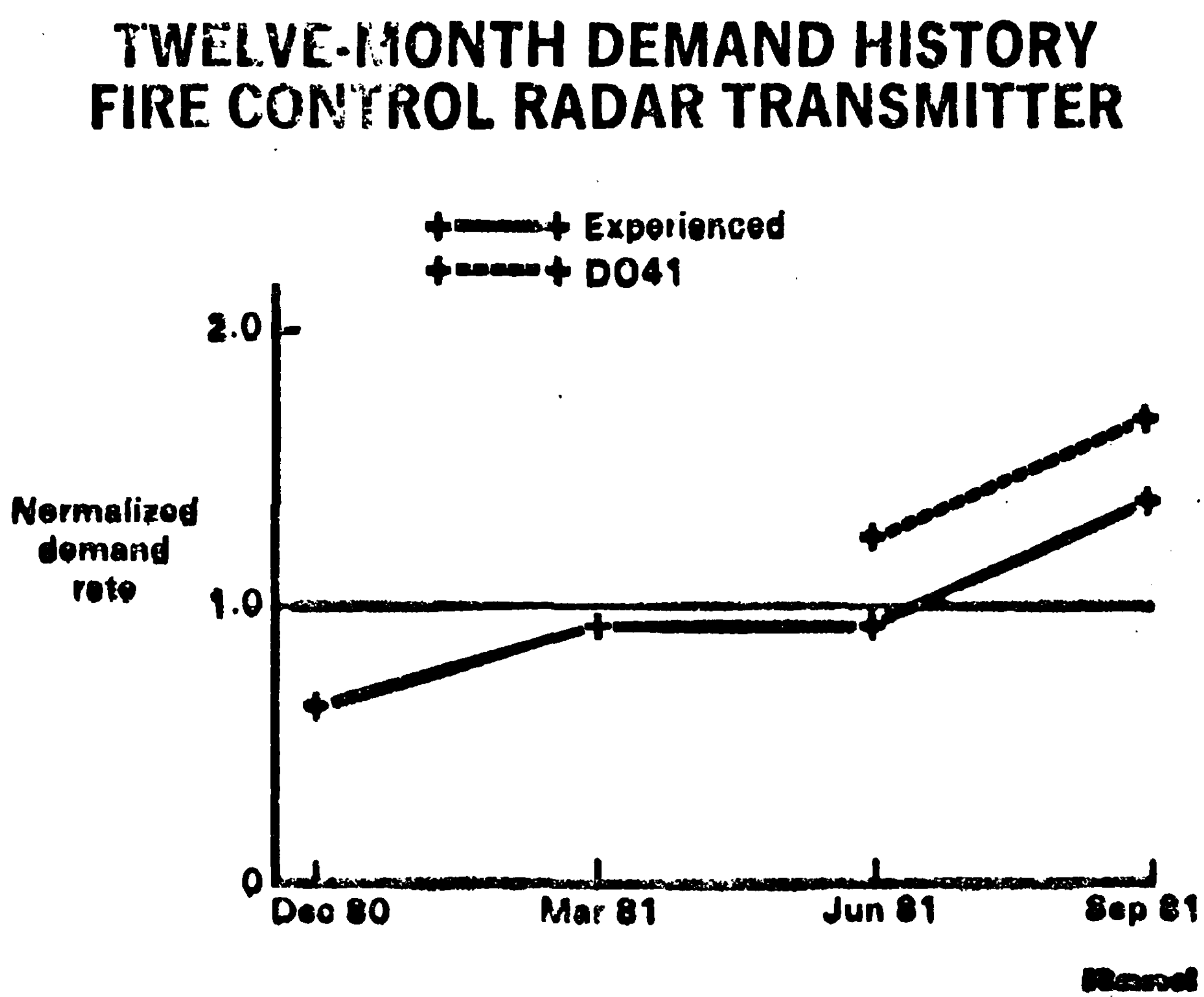

TWELVE-MONTH DEMAND HISTORY
FIRE CONTROL RADAR TRANSMITTER
Experienced
D041
2.0
1.0
0
Normalized
demand
rate
Dec 80
Mar 81
Jun 81
Sep 81

Figure 2

COMPARISON OF DYNA-METRIC EXTENDED WITH AFRAMS SAMPLE

Item	Base repair		In transit		Pipeline		Backorders	
	Mod.	AFRAMS	Mod.	AFRAMS	Mod.	AFRAMS	Mod.	AFRAMS
F. C. radar ant	9.80	10.00	12.01	18.33	82.04	87.33	8.81	26.33
F. C. radar tx	5.36	7.00	13.58	10.67	90.55	58.67	21.96	12.00
INU	8.49	4.00	12.11	22.67	86.10	63.00	16.05	9.67
HUD	1.15	3.00	2.81	0.00	31.22	37.30	2.89	3.33
AOA tx	0	0	7.57	23.67	61.10	46.67	9.36	10.33

Table 1

that we may be using incorrect data in the model, one is cautioned against drawing any inferences from the chart. Most of the differences in the table may be explained by improper data-demand or NRTS rates, or depot repair cycle. However, we can only make that assessment after we have the March 1982 D041 data base. Due to some peculiarities in the AFRAMS data, the base repair columns reflect the quantity in repair at all F-16 operational bases except Hill AFB. Also, the in-transit column only reflects the serviceable assets in transportation to bases. The total pipeline figures reflect the total assets in either the base or the depot repair pipeline. It is interesting to note that the model, like METRIC, computes depot backorders and allocates them to the base pipelines. The model numbers displayed in the table reflect this. The AFRAMS backorder numbers actually reflect the quantity reported as Due Out of Maintenance. I believe this figure most accurately reflects what the model reports as a backorder. Once we have the D041 quarterly factors, we will rerun the model to compute the pipeline values to compare with the AFRAMS sample. Statistical tests will then be performed to determine whether differences can be explained by random variation or by other causes. If there are many significant differences, we will discuss the differences with the appropriate Item Managers in an attempt to determine what is really happening. Armed with this knowledge, we may then be in a position to suggest enhancements to the model.

That, in essence, is how we are conducting our test. In some regards, we may be asking the model to do more than can be expected, but we are doing this to increase our understanding of how dynamic pipelines behave. If the model is ever to be used to redistribute assets from one unit to another, and I believe it will, we must have this knowledge. Furthermore, if the model does not perform well in the test, it should not be considered an indictment against Dyna-METRIC, but rather against the theory contained in all major inventory models in use today. In that sense, the test is designed to be a learning exercise with wide applications.

Copy No. __________

Contract No. __________

Special Instructions __________

WORKING DRAFT

ANALYTICALLY MODELING THE CONSTRAINED REPAIR PROBLEM

Gordon B. Crawford

March 1982

WD-1460-AF

Prepared For United States Air Force

Rand
SANTA MONICA, CA 90406

PREFACE

This report is a write-up of a briefing presented by the author at the 1982 USAF Logistics Capability Assessment Symposium held at the Air Force Academy in Colorado Springs in March. The research was performed in the Resource Management Program under the Project AIR FORCE project "The Driving Inputs and Assumptions of Stockage/Assessment Models."

ANALYTICALLY MODELING THE CONSTRAINED REPAIR PROBLEM

Gordon B. Crawford
The Rand Corporation
March 1982

THE PROBLEM

For its most recent combat aircraft, the Air Force, and the other services, have increasingly used avionics suites that rely on expensive automated test equipment (ATE) for repair. Several characteristics of this trend present an added challenge to the logistician concerned with wartime capability: 1) These avionics units are expensive and in some important cases in short supply; 2) they are complex and fault isolation can be difficult; 3) repair without the ATE is generally impossible at the base level; and 4) the ATE are expensive, in short supply, and also subject to failure.

It is not surprising then that this test equipment may operate at near capacity in peacetime. In a wartime environment, especially in NATO, avionics repair demands may cause significant ATE queuing, resulting in an important impact on capability. The firepower available to both sides in a NATO war suggest that the escalation of hostilities and surge in flying activities will be abrupt, and the success of either side in the first days or weeks maybe irreversible. The very dynamic nature of this surge and its importance makes modeling this queuing of avionics a challenge to the analyst.

Several properties of the test equipment exacerbate the queuing problem. The equipments are not only expensive, in short supply, and failure prone, they are also big. Aircraft will be deployed much more rapidly than the supporting ATE, thus increasing the load on the limited test equipment already in Europe.

Not only is this queuing problem important, it also has complexities that make it more challenging than analogous problems citied in mathematical literature. For example, the intensity of the surge and its importance preclude steady state approximations. In addition, the number of servers may not only change in a deterministic manner as ATE are deployed, but it may also change at random as they fail. Perhaps most importantly, service (repair) priorities will not be first-come-first-served (FCFS). The real world service priorities can be expected to approximate a rule in which that component causing the most downed aircraft is served next.

In this description of the constrained repair problem we have focused attention on the ATE queuing problem. There are many other queuing problems caused by constrained service capability such as the effect of limited manpower on repair, the limits of depot repair, flight line turn around time as constrained by POL facilities, etc. The ATE queuing problem has been singled out because of its importance and the relative inflexibility of the ATE itself. In many other instances of constraints it is reasonable to believe that in wartime the limit on service capacity will be mitigated by the flexibility of manpower and efficient deviations from standard procedures. In the case of ATE, it is often impossible to reduce the considerable service time required on the test equipment to isolate a fault or verify that the unit has been repaired. This inflexibility of the ATE makes inappropriate and misleading the common and mathematically convenient "ample server" assumption that pervades some of our capability assessment models.

In this paper we will discuss the tools commonly available to the analyst and then give a mathematical statement of the problem. Deriving a numerical solution requires imposing additional assumptions, some of which are unreasonably restrictive. The last sections show how the procedure has been modified to reduce or avoid the impact of these assumptions.

THE TOOLS

In addition to the numerical solution procedure described in this paper several other tools are available to the analyst.

In the case where arrival intensities are zero and then jump up to a constant level, and we can make the infinite or ample server assumption, the closed form solution for the number of parts in the system is well known. (Takacs, L., Introduction to the Theory of Queues, Oxford University Press, New York, 1962) While these assumptions are unduly restrictive, the closed form solution provides a valuable benchmark to check the accuracy of more complex models.

Dyna-Sim, a Monte Carlo model of the ATE queuing problem, has been developed at Rand by Lou Miller. Dyna-Sim provides the opportunity to compare different assumptions about the repair time distribution (see below) as well as different service priorities. In addition it provides a benchmark to check the accuracy of the analytic solution described below.

A Monte-Carlo procedure, such as Dyna-Sim, has drawbacks that restrict its usefulness for incorporation in larger capability assessment models such as Dyna-METRIC and WARS. The queue in a saturated system is highly variable and achieving a given degree of

accuracy with a Monte-Carlo model may require a large number of time consuming runs. Largely for this reason we have pursued an analytic solution to this queuing problem that is compatible with Dyna-METRIC and WARS.

THE MATHEMATICAL ASSUMPTIONS

The real world queuing problem presented by ATE would seem to be characterized by:

1. A collection of different incoming parts, LRU(I), I = 1, 2, ..., N
2. Each having a mean service time T(I),
3. A time varying arrival intensity H(I,T),
4. An initial level of serviceable stock SL(I),
5. A (possibly random) number of servers S(T).

In this queuing problem let N(I,T) be the random number of units of LRU(I) in the queue and in repair at time T. Effective real world service priorities may be approximated by assuming that the first available server services that LRU in the queue having the maximum back order quantity BOQ(I), BOQ(I) = N(I,T) - SL(I).

Throughout we will assume that parts fail (i.e., arrive at the queue) according to a Poisson arrival process with a nonstationary arrival intensity given by 3. (For a discussion of Poisson and compound Poisson arrival processes see Crawford, G. B., Palms Theorem for Nonstationary Processes, The Rand Corporation, R-2750-RC, August 1981.)

THE NUMERICAL SOLUTION

To develop an analytic solution to this problem, we impose a number of additional or revised restrictions on the structure stated above, some of which are unduly restrictive, and give a simple differential equation approach to solving this simplified problem. To begin we make the additional assumptions:

6. There is only one type of LRU and it has arrival intensity

$$H(t) = \sum H(i,t)$$

and service time

(i) $$T = \sum C(i)T(i),$$

where $C(i) = H(i,t)/H(t)$ doesn't depend on t.

7. The number of servers, S(t), is constant and known.

8. Parts are served on a first-come-first-served basis.

9. Repair times are exponential random variables.

In subsequent sections we show how to modify this procedure to relax or avoid the unrealistic assumptions 6 through 8.

With these assumptions this process has all the attributes of what is known in the literature as a nonstationary M/M/S queuing process. For our purposes it is only necessary to note that with the assumption of exponential repair times this process is a Markov process.

Markov processes are characterized by two interrelated properties:

A. They have the "lack of memory" property; (roughly speaking, given the present the future is independent of the past), and

B. The transition probabilities for all future times are given by the solution to a set of simultaneous differential equations (called the Chapman-Kolmogorov equations).

This second property holds promise. Computers are very good at numerically solving differential equations.

To describe this procedure let

(ii) $N(t)$ = the number of units in the system at time t,

and

(iii) $$P(N,t) = Pr(N(t) = N).$$

Here, and in the sequel, "in the system" means in the queue or in repair.

As mentioned above $N(t)$ is a Markov process and we can solve for the $P(N,t)$ by solving the Chapman-Kolmogorov differential equations. To implement this procedure let $P(t)$ be the vector of $P(N,t)$, $N = 0,\ldots,max$:

(iv) $$P(t) = \begin{Bmatrix} P(0,t) \\ P(1,t) \\ \cdot \\ \cdot \\ \cdot \\ P(max,t) \end{Bmatrix}$$

To numerically solve for P(t) we let time increase in increments of length d and note that the difference equations we get from the Chapman-Kolmogorov equations show that

(v) $$P(t + d) = D_S \cdot P(t)$$

where D_S is a matrix which depends on d as well as the number of servers S. It should be noted that as d gets very small the left side of this equation converges to P(t), and thus D_S must converge to the identity matrix. In fact, it follows from the difference equations that D_S is always tridiagonal--it has entries on the main diagonal which are slightly less than one and entries on the two adjacent diagonals which are slightly larger than zero. All other entries are zero.

To solve for P(t) we use the equation (v) and "boot strap" the solution through time in increments of length d. To begin we assume that the queue is empty at time 0:

(vi) $$P(0) = \begin{Bmatrix} P(0,0) \\ P(1,0) \\ \cdot \\ \cdot \\ \cdot \\ P(max,0) \end{Bmatrix} = \begin{Bmatrix} 1 \\ 0 \\ \cdot \\ \cdot \\ \cdot \\ 0 \end{Bmatrix} .$$

(Other assumptions regarding the queue at time 0 could be made, the only restriction is that the sum of the column in (vi) be equal to 1.) With this notation

(vii) $$P(d) = D_S P(0),$$

(viii) $$P(2d) = D_S P(d) = D_S^2 P(0).$$

More generally, if t is a multiple of d, t = nd,

(ix) $$P(t) = D_S^n P(0).$$

Computationally this procedure is fast and accurate. To test the accuracy we have run problems with steady state arrivals and compared the solution to the closed form analytic solution mentioned above. The solution to a saturated queuing problem, taking d = 1/20, and a 20 day scenario, executed in less than two seconds of CPU time and resulted in errors less than 10^{-4}.

Bootstrap techniques for solving differential equations often have the disadvantage that errors are cumulative. Markov processes have an advantage here in that it is known that when a steady state solution exists, the process tends to this solution regardless of the initial conditions. This is important for the bootstrap technique because it implies that round off or calculational errors early in the numerical process get "washed out" and do not effect the accuracy in the later days of the computation.

CONCERNING THE EXPONENTIAL ASSUMPTION

The one assumption that we will not relax is that the repair times have an exponential distribution.

Since this assumption will rarely be satisfied in nature we have investigated the impact on the performance of the queue of two very different repair time distributions, the exponential distribution and the degenerate or constant distribution.

For this comparison we used the Dyna-Sim Monte-Carlo model mentioned above and compared the output of runs where 1) the repair time for LRU(I) was always T(I) and 2) the repair times for LRU(I) was an exponential random variable with mean T(I).

The scenario for this comparison uses arrival rates and repair times that could be representative of a deployed wing of tactical fighters with two complete and operational suites of test equipment. We are modeling 5 different LRUs that get tested on one stand of the ATE suite. The maximum back order quantities given are the maximum over these 5 LRUs. In short we are modeling 5 different LRUs and 2 operational servers in a war time environment.

The results, rounded to two decimal places, are given in Fig. 1. In three cases, denoted by "-", the constant service times yielded a slightly increased performance. In three other cases, denoted by "+", the constant service times did worse. In the remaining three cases the results were the same to two decimal places. These results strongly suggest that if we use the same mean repair time the choice of repair time distribution is unimportant in this saturated queuing problem.

It should be noted that the modeler does not always have this latitude in choosing a repair time distribution. In problems where the ample server assumption can be made it has been shown (Crawford, G. B., ibid) that this latitude does not exist and the variance of the repair time is also important.

Apparently saturated queuing problems are driven by the arrival rates and the mean service time required. Based on Fig. 1, it seems that the choice of repair times having this mean is unimportant and we can assume the exponential distribution with relative impunity.

MODELING A TIME VARYING, OR RANDOM, NUMBER OF SERVERS

In the process of developing a technique to solve the Chapman-Kolmogorov equations we imposed a number of unrealistic assumptions whose impact will be reduced by changes introduced in the following sections. The last of these (number 7. above) was that the number of servers, S, was fixed and known. For instance, knowing S = 2 allows us to solve for P(t+d) given P(t):

Is the exponential repair time important?

- o It is important to this numerical procedure
- o Does it alter the description of the queue?

Dyna-Sim results (F-XX scenario)
Exponential Repair Times/Constant Repair Times

	Day 10	Day 15	Day 20
Pr(max BO $\leq$ 6)	.98/.98	.80/.85-	.57/.57
Pr(max BO $\leq$ 4)	.88/.89-	.60/.60	.34/.28+
Pr(max BO $\leq$ 2)	.66/.69-	.30/.26+	.16/.10+

Fig. 1 -- Exponential vs constant repair times

(xi) $$P(t+d) = D_2 P(t).$$

More generally, if d = 1/100, then (taking day 3 and 4 for example):

(xii) $$P(4) = \underbrace{D_2 \; . \; . \; . \; D_2 D_2 D_2}_{\text{100 operations}} \; P(3).$$

Suppose, on the other hand, that the number of servers on day 3 is random and Ex S(t) = 1.4 for $3 \leq t \leq 4$. We can model this in an expected value sense by letting

(xiii) $$P(4) = \underbrace{D_2 \; . \; . \; . \; D_2 D_2 D_1 D_1 D_1 D_2 D_2 D_1 D_1 D_1}_{\text{100 operations}} \; P(3).$$

In equation (xiii) we have divided the 100 applications of D up into groups of five, and each group of five is composed of two applications of D_2 and three applications of D_1, giving an average of 1.4 servers over this 24 hour period.

Modeling a random number of servers this way has two shortcomings. It captures only the mean value of the distribution of the number of servers, not the true random variation. In a saturated queue this is not important, but in an unsaturated queue it will give results which are slightly optimistic. Second, the numerical result of applying a mixture of the operators D_2 and D_1 depends on the order in which the

operators are applied. This is an example of the non-commutativity of matrix multiplication: if A and B are matrices then, in general

$$AB \neq BA. \tag{xiv}$$

However, if either A or B is equal to the identity matrix, then equality holds in (xiv). This is helpful because in the discussion following equation (v), it was mentioned that D_S was <u>almost</u> equal to the identity matrix. As a result, the left side of (xiii) does depend on the order of the operations, but numerically the dependence is very small and for our purposes can be ignored.

MODELING DIFFERENT LRUS TREATED BY THE SAME CLASS OF SERVER

It follows from assumption 6 that if we randomly pick an LRU from the job stream coming into the queue, it will be of type LRU(i) with probability C(i). By the same token, if we know there are N total LRUs in the queue then N(i,t), the number of LRU(i) in the queue is equal to m with the binomial probability

$$Pr(N(i,t) = m | N) = \binom{N}{m} C(i)^{m} (1 - C(i))^{N-m} \tag{xv}$$

In the preceding sections we showed how to calculate P(N,t), the distribution of the total number of LRUs in the system at time t. Since the number of servers is known P(N,t) can be used to find the distribution of m, the number of LRU(i) in the queue. The distribution of N can then be used to uncondition the distribution of N(i,t) in equation (xv).

By the same token it can be shown that if an LRU is taken at random from repair (as opposed to being taken from the queue) the probability that it is LRU(i) is given by

$$C(i)T(i)/\sum C(i)T(i). \qquad \text{(xvi)}$$

If we are given that the number of LRUs in repair is equal to L, then the conditional distribution of the number of those that are LRU(i) is binomial with parameters L and the probability in expression (xvi). Again, using P(N,t) we can uncondition this distribution and solve for the distribution of the number of units in repair.

Our interest is in the number of units in the system, i.e., in repair or in the queue. The distribution of the sum of these two random variables can be calculated from the results above, but in most important cases it is much easier.

Due to the very severe limitation on the number of stands of ATE (virtually never more than 2), it follows that the preponderance of LRUs will be in the queue, not in repair, during the demanding times of the surge. Accordingly, we can calculate the distribution of N(i,t) as though P(N,t), the distribution of the number of units in the system (in the queue plus in repair), was the distribution of the number of units in the queue. This approximation will be very close if C(i) is approximately equal to expression (xvi), i.e., if the T(i)'s are nearly the same.

Using either this simplified method, or the more detailed method described above, we have shown how to calculate (to within a good

approximation) the distribution of N(i,t), the number of LRU(i) in the system at time t, subject to the assumptions 1 through 5, and the FCFS assumption 8.

AVOIDING THE FCFS ASSUMPTION: A QUEUING SYSTEM WITH CRITICAL AND NON-CRITICAL COMPONENTS

The above has all been built on the assumption that the process is Markovian and hence described by the Chapman-Kolmogorov equations. The Markovian nature of the process is not changed if we assume that we have, a priori, identified two classes of assets, critical and non-critical, and repair the critical assets on a priority and preemptive basis, but service on a FCFS basis within each class.

In this case, the numerical solution procedure is more time consuming. Before we solved a system of "MAX" differential equations, where MAX is taken large enough that the probability of more than MAX units in the system was negligible. With two classes of assets we must solve a system of MAX^2 differential equations. With some attention to the computer programming this numerical solution can be computed for a twenty day scenario in 10 to 15 CPU seconds on an IBM 3033 computer.

The difficulty with this two classification system lies in the dynamic nature of what is critical. If one defines the class of critical assets narrowly one or more of the non-critical assets become the driving consideration in the calculation of NMCS aircraft. On the other hand, if one defines the class of critical assets broadly, there will be one or more very critical LRUs that do not receive adequate priority within the class of critical assets. These LRUs then begin to drive the number of NMCS aircraft.

To avoid this situation we have written a program that stops the iterative calculation once a day and computes Pr(N(i,t) = m) for each LRU(i) and all m. Based on these distributions and SL(i), the initial stock level for LRU(i), the program computes BOQ(i), the expected number of backorders for LRU(i). Based on the BOQ(i) the program then redefines the classes of critical and non-critical assets. If the class of critical assets has changed, then, using the Pr(N(i,t) = m) the queue is redefined. If the class of critical assets remains unchanged, the iterations begin again with the results of the previous days calculation.

To define the critical and non-critical assets on the basis of BOQ(i) the program divides the LRUs into two classes, each with at least one asset. The division is made by ordering the BOQ(i) and then dividing these points where the gap between adjacent neighbors is the greatest. This procedure for defining clusters has been shown to be optimum under fairly robust conditions. ("An Optimization Approach to a Clustering Algorithm," C. D. Roach, Ph.D. thesis, Southern Methodist University, July 1971). In addition the procedure yields clusters that generally have the minimum possible within cluster variance.

SUMMARY

The procedure we discuss here has avoided or mitigated the unrealistic assumptions that were originally imposed. It is being implemented at Rand in an in-house version of Dyna-METRIC for comparison with the currently used approximations for the finite server problem. It yields the marginal distribution of the number of each LRU(i) in the system at any point in time. In this sense it is appropriate for

AF MANAGED
CONTRACTOR OPERATED

- ADVANTAGES
  - REDUCE ENGINEERING REQUIREMENTS
  - REDUCE FACILITY REQUIREMENTS
  - REDUCE EQUIPMENT REQUIREMENTS
  - MINIMIZE CONFIGURATION MANAGEMENT COMPLEXITY

USAF MANAGED
CONTRACTOR OPERATED

- INTIATIVES
  - STANDARD EMS OPERATIONAL FLIGHT PROGRAM
  - STANDARD EMS RED TAPE
  - STANDARD EMITTER IDENTIFICATION DATA
  - [illegible] OF EQUIPMENT
  - [illegible]
  - [illegible] SYSTEM

USAF MANAGED-CONTRACTOR OPERATED

- USAF RESPONSIBILITY
  - MANAGEMENT & CONTROL
  - TECHNICAL INTERFACE/DIRECTION
  - INDEPENDENT VALIDATION & VERIFICATION
- CONTRACTOR RESPONSIBILITY
  - DEVELOP INITIAL SOFTWARE
  - DEVELOP INTEGRATED SUPPORT STATION
  - PROVIDE FOLLOW-ON SUPPORT
- ADVANTAGE
  - REDUCES REQUIREMENTS FOR USAF ELECTRONIC ENGINEERS

CASES IN NEGOTIATION

• PEACE JAY	AN/ALR-69
• PEACE NOVA	AN/ALR-69
• PEACE NOVA	AN/ALQ-131
• PEACE DELTA	AN/ALR-46
• CLASSIFIED COUNTRY	AN/ALQ-119
• CLASSIFIED COUNTRIES (7)	AN/ALQ-131
• CLASSIFIED COUNTRIES (3)	AN/ALR-69
• PORTUGAL	AN/ALR-46
• EPG	AN/ALR-69
• ISRAEL	AN/ALR-69
• SWITZERLAND	AN/ALR-46

CURRENT CASE WORKLOAD

o	NETHERLANDS	AN/ALQ-131	*
o	SAUDI ARABIA	F-15 TEWS	
o	EGYPT	AN/ALR-46	
o	EGYPT	AN/ALR-69	*
o	EGYPT	AN/ALQ-119	*
o	AUSTRALIA	AN/ALR-62	
o	TAIWAN	AN/ALR-46	
o	TURKEY	AN/ALR-46	*
o	PAKISTAN	AN/ALR-46	*
o	PAKISTAN	AN/ALQ-131	*
o	KOREA	AN/ALR-69	*

* **NO DEDICATED ENGINEERING SUPPORT**

SECURITY ASSISTANCE SOFTWARE SUPPORT (SASS) DEFINITION

- SOFTWARE SUPPORT CONCEPT
  - INITIAL SOFTWARE
  - DEDICATED RESOURCES
  - FOLLOW-ON SUPPORT

EW SOFTWARE

OPERATIONAL FLIGHT PROGRAM

- PROPERTIES
  - EXECUTIVE PROGRAM
  - ALGORITHMS
  - GUIDANCE
- RELEASABILITY
  - USAF STANDARD
  - FMS PECULIAR

EMITTER IDENT TABLE

- THEATER OF OPERATIONS SENSITIVE
- PROPERTIES
  - THREAT LIBRARY
  - PRIORITIES
  - SYMBOLS
- INTELLIGENCE SOURCE
  - COUNTRY PECULIAR
  - USG ASSISTANCE

MANAGEMENT: Within the Division, there will continue to be a requirement for support from all functional areas, logistics, item management, production management, and engineering. Functionally, there will continue to be direct requirements within logistics and engineering. The engineering group performs four functions: plans and programs, operations, tech services, and facility operations. Contractor support will operate under engineering operations and includes the SASS operations contractor(s) and the independent validation and verification contractor.

EQUIPMENT RESOURCES: We will require an integrated support station to support the AN/ALR-46, AN/ALR-69, and the AN/ALQ-131. This equipment would support accelerated aircraft schedules and IOC dates that are earlier than equipment lead times.

FACILITY RESOURCES: We have renovated Bldg 229 in an effort to increase its useful life. With current and projected requirements the north end is saturated and, in fact, there are equipment stations planned for the south end. In addition, we have identified over 10K square feet for personnel. If FMS requirements continue to expand, long term facility needs will have to be addressed.

ACTION: To effectively implement our proposal, we recommend that HQ USAF (1) approve the SASS concept, (2) approve a program management directive, and (3) gain approval from DSAA fpr use of administrative funds.

CURRENT CASE WORKLOAD: To better understand the engineering shortfall, you must understand the currect workload. We currently have signed LOAs for 11 countries and systems. All require engineering support although only nine are supported under the USAF managed SASS concept. Dedicated engineers are available for only three of the 11 programs.

CASES IN NEGOTIATION: Most alarming, however, is the number of cases that are currently in negotiation, 19 total. Only 15 would be supported under the SASS concept, but again, all require engineering resources. Since November 1982, case workload has increased 27% and cases in negotiation have increased from 12 to 19 (+58%).

ALTERNATIVES: Because of this we have been forced to look at alternative approaches to support FMS. These include a country to contractor (direct) approach, USAF managed and operated approach and a USAF managed-contractor operated approach.

ASSUMPTIONS: We based our analysis and discussions on certain assumptions. The assumptions included: (1) minimizing the impact on USAF programs, (2) a continuously expanding FMS workload, (3) the use of dedicated resources to support FMS, and (4) an inability to fill electronic engineering vacancies within the Electronic Warfare Division at the current time and through the short term.

USAF MANAGED-CONTRACTOR OPERATED: Because of the requirement to maintain control of intelligence information and to limit the drain of a shrinking engineering manpower pool, the direct and USAF operated support concepts were eliminated. An analysis of the contractor operated concept indicated that the USAF could maintain management and control, technical interface, and still control the independent validation and verification effort. The contractor would continue to provide initial software development, and development and integrated of the ISS. He would not, however, provide all the follow-on support. Follow-on support was expanded to include validation and verification of software by a separate, independent contractor under USAF control. The advantage here is a reduction in the rate of increase for USAF engineers. Additional initiatives under the new USAF managed-contractor operated SASS concept include increased standardization of some portions of EW software, joint use of equipment under an EW Standardization and Improvement Program, and increased use of alternate skills. These initiatives minimize the complexity of configuration management, reduce equipment and facility requirements, as well as engineering personnel requirements.

RECOMMENDATION: Our recommendation is to implement the USAF managed, contractor operated support concept. This concept has been defined in the WR-ALC EW Support Plan for Security Assistance and reviewed by the AFLC and ILC staffs. It includes identification of a separate and dedicated facility as well as additional prepositioned equipment to support FMS. Funding for this revised SASS plan would be through the use of FMS administrative funds with a payback from case funds in a revolving type account which must be approved by the Defense Security Assistance Agency.

IMPLEMENTATION: In order to implement this concept, there is some impact on management as well as personnel, equipment, and facility resources.

implemented as originally envisioned, however, for several reasons. First, as you now know, there is no such thing as a standard FMS configuration. Secondly, the cooperation and funding required never materialized as planned. Although the country of Iran planned to fund the initial program, their change in governments left the project unfunded.

SOFTWARE POLICY LETTER: In 1980, AFLC/CV recognized the non-standard requirement of EW software and in a letter to AFSC established the support procedures for embedded computer systems. This policy letter identified the SASS concept and established some guidelines. Among those guidelines were the fact that we would use dedicated facilities, equipment and people to support FMS, and contractors would be used to provide the deliverables. Although the full direction of this policy letter has not yet been included in AFLCR 800-21, it is the basis for our support concept today, and as a result we are building five (5) SASS stations right now with four (4) others under different stages of planning and construction.

PERSONNEL REQUIREMENTS: In order to support the SASS concept, we have personnel requirements in all the functional disciplines within the Electronic Warfare Division. We have dedicated and direct requirements in both the Logistics Management and Engineering Branches only, however.

DIRECT ENGINEERING REQUIREMENTS: We are primarily concerned with our direct engineering requirements. Based on our experiences within the EW Avionics Integrated Support Facility (EWAISF), it is our technical judgment that it takes four (4) electronic engineers to support FMS ISS requirements. This support is based on a mix of USAF and contract engineers. Our current approach calls for one (1) USAF engineer, one (1) USAF electronic technician, and two (2) contractor engineers for each system for each country.

LIMITATIONS: The current SASS concept has several limitations, however. These limitations are primarily in the funding and electronic engineering resources areas. For example, because monies cannot be expended until the Letter of Offer and Acceptance (LOA) is signed, we cannot hire or acquire engineers to support a particular program until then. Typically, such engineers may not be system or software qualified. This forces a new engineer to simultaneously develop statements of work and perform other engineering duties while actually learning the system and its characteristics. Likewise, because you can't spend money before LOA signature, we cannot preposition equipment needed to develop or maintain the software. In other words, the software is equipment dependent. Because of this, initial software developments which only require 10-12 months of effort take 34 months because of long equipment lead times. This prevents us from supporting accelerated aircraft programs or initial operational capability (IOC) dates earlier than these lead times. Facilities, too, present a limitation. We currently are rehabilitating Bldg 229 at WR-ALC. As sales accelerate and program requirements increase, we begin to approach the civil engineering limits for facility renovation. The most critical limitation, however, is the DOD and industry wide shortage of electronic engineers (EE). WR-ALC is especially affected because of its high requirement for EEs. For example, as of early February 1982 we are 58% manned for EEs. We have 108 engineers assigned and are authorized 187.

INTRODUCTION: This briefing is designed to clarify the support procedures for reprogrammable EW systems sold to foreign governments under approved Foreign Military Sales (FMS) cases.

OVERVIEW: We will review the specific purpose, FMS background including our current support concept, some alternate proposals for support, our recommendation and the actions required to implement our proposal.

PURPOSE: It is our purpose to identify and implement a comprehensive support strategy for airborne electronic warfare systems sold to foreign governments.

FMS BACKGROUND: As you know, in the past we have primarily sold hardware systems under FMS. These systems had a standard configuration and generally provided minimum impact on Air Force support. For example, if the Air Force fielded a TCTO, we simply offered it to the foreign user and then ordered additional units which were exact duplicates of USAF requirements. Today, however, we are heavily involved with software and reprogrammable systems. These systems generally have a standard hardware configuration but divergent software. Because of this, we in AFLC are required to support a non-standard system and configuration.

EW SOFTWARE: In order to better understand the differences in software within EW, we have purposely divided EW software into two (2) distinct categories, the Operational Flight Program (OFP) and the Emitter Identification Data (EID) table. The OFP is the master or executive program that contains guidance information generated by ground or airborne missiles and artillery. Although USAF OFP information is used as a baseline, changes to the OFP, because of national disclosure policy or differences in threat information, create an FMS peculiar OFP. The EID is known as the threat library and contains threat information, order of battle priorities and threat symbols. Each EID is based on intelligence information and data provided by the using country. And although some U.S. government assistance may be required, the EID is completely country peculiar. You can understand, therefore, that when the software is different the system becomes different. That's why the ALR-69 we sell to Egypt, Korea or the European Participating Governments (EPG) is different than the ALR-69 we sell to Israel.

CURRENT SUPPORT CONCEPT: We currently support EW software under a concept called Security Assistance Software Support (SASS). This concept has evolved over the years and has certain requirements as well as limitations.

SASS DEFINITION: The SASS concept is a three phased support strategy that includes (1) an initial software development, (2) dedicated facility and equipment development and integration, and (3) follow-on software support. During the initial software development, a contractor delivers the EW software after integrating and testing the OFP and EID information. Concurrently with the software development, a facility is constructed at WR-ALC to house the integrated support station (ISS) and other equipment used to support the software and hardware. The final phase includes follow-on support for the routine and emergency changes required to the software.

ORIGINAL SASS CONCEPT: The original SASS concept was developed in 1978 to support the European Participating Group (EPG) and was based on a standard configuration. It too included a dedicated facility and personnel, but was dependent on mulit-national cooperation, funding and support. It was never

SUPPORT FOR ELECTRONIC WARFARE (EW)

SYSTEMS SOLD TO FOREIGN GOVERNMENTS

Prepared by
Capt Michael W. Lennon
WR-ALC/MMR/AV 468-3791
24 Feb 82

SECTION V - ADDITIONAL PAPERS

This section includes three additional papers that were not presented at the symposium.

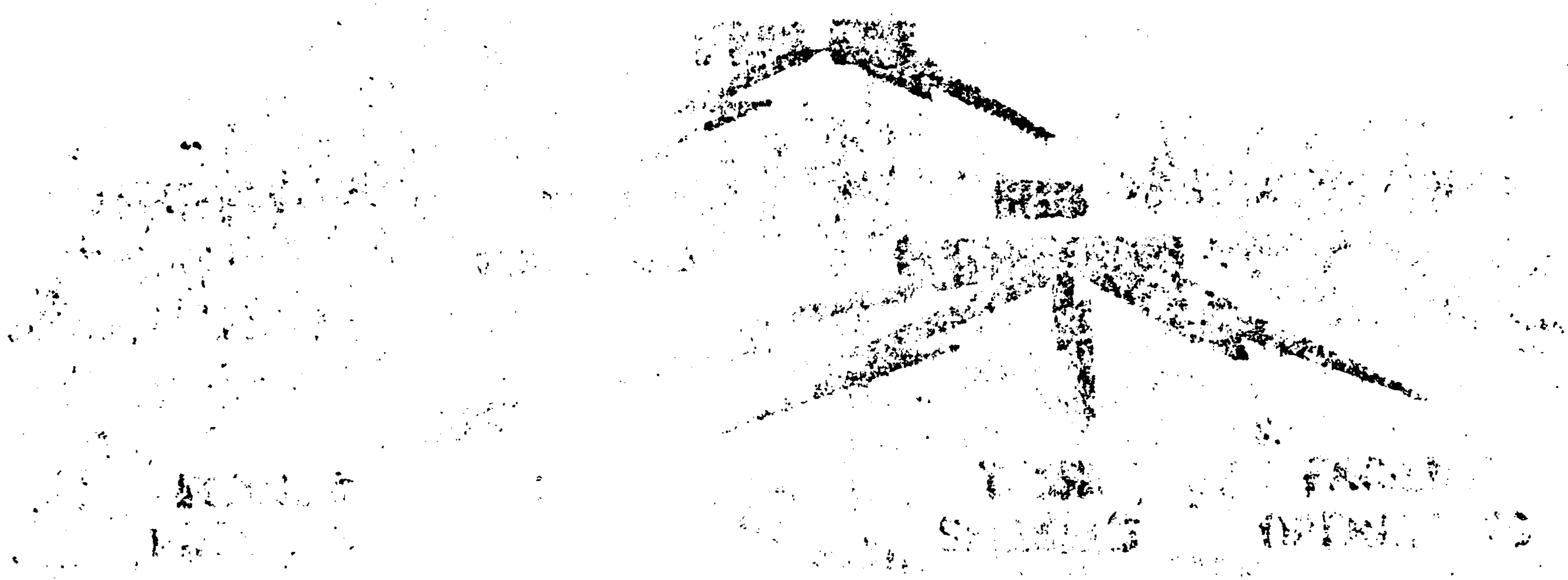
Additionally, copies of the Tuesday afternoon seminar on Planning, Programming, Budgeting and the Air Force are provided.

Finally, a copy of Lt Col Campbell's presentation "Where Do We Go From Here" is included.

inclusion in Dyna-METRIC or WARS or other models which compute pipeline quantities by LRU.

Applications, other than ATE, are being considered. There are many instances of other repair constraints which have been loosely treated by modelers and may benefit from this approach.

NAGEMENT



FLIGHT SAFETY PREDICTION TECHNIQUE

ABSTRACT

The Flight Safety Prediction Technique (FSPT) is a methodology for identifying and evaluating flight safety problems caused by equipment malfunctions. This method provides otherwise unavailable information concerning aircraft design, malfunction trends and the significance of these trends with respect to safety. This information can be used to quantify aircraft operations, equipment and events in terms of their relative contribution to unsafe conditions.

The minimization of personal injury and property damage is the objective of all safety efforts. Safety, when defined as the absence of the potential for injuries and damages, is typically quantified in terms of the total dollar loss resulting from mishaps in operation. The amount of property damage or personal injury resulting from an aircraft mishap, however, is often determined by conditions external to the aircraft system.

The dollar-loss quantification parameters is a legitimate and useful after-the-fact performance indicator, but is of little value in assessing the importance of safety problems that have not yet caused dollar loss. The mathematical model presented in this paper provides a means of evaluating unsafe conditions by quantifying the safety effect of a component failure and combining the value obtained with the probability of the failure's occurrence.

By: Herbert Chessman
HQ SAALC/MMEAI
Kelly AFB, TX

OUTLINE

		PAGE
I.	INTRODUCTION	1
	PURPOSE	1
	BACKGROUND	1
II.	DESCRIPTION OF MATH MODEL	3
	DEFINITIONS	3
	DESCRIPTION	4
	EXAMPLE	9
III.	VALIDATION	12
IV.	APPLICATIONS	14
	Table 1, Major Functions	5
	Table 2, Provisory Factors	8
	Figure 1, Function Diagram	10
	Table 3, WUC List	11
	Table 4, Validation Results	13

I. INTRODUCTION

PURPOSE:

Traditional safety analysis consists of extrapolating historical mishap rates into probable future rates. The year-by-year occurrence of such estimates is partly a function of how judiciously the predictor selects and screens his mishap data. These predictions can be quite accurate when equipment characteristics, maintenance level environments, and pilot skills are consistent with those existing when the mishap rates were calculated. Often, however, adverse changes in areas critical to safety are recognized only after the accident rate has been found to be higher than expected and investigations have isolated the causes.

The system manager needs a data system which will not only predict failure patterns and forecast the impact of failures on the system, but will also be useful in determining problem causes and in evaluating proposed solutions.

The Flight Safety Prediction Technique (FSPT) is a method of quantifying the safety impact of equipment failures. This quantification is called "sensitivity." When an equipment sensitivity is combined with the probability of the equipment's failure, the risk or "criticality" is quantified.

Trending criticalities forecasts impending flight safety problems so that corrective action can be taken before mishaps occur. High sensitivity with high criticality implies that a configuration change is needed while low sensitivity with high criticality indicates that a significant reliability improvement will reduce risk.

BACKGROUND:

FSPT began in 1965 when ARINC Research Corporation engineers realized that a computer assisted Failure Modes and Effects Analysis (FMEA) method that they were using could be developed into a safety assessment model.

II. DESCRIPTION OF MATH MODEL

DEFINITIONS:

The definitions of terms which have particular meaning in FSPT will contribute to understanding the following description:

a. a. The criticality of a Work Unit Code (WUC) is the proportion of sorties in which the aircraft will enter a hazardous mode due to material failures of that WUC.

b. Failure of a WUC is a maintenance action reported in D056 and charged with pilot discovery, a true failure malfunction and a repair or replacement corrective action, i.e., when Discovered Codes A-E, Type I How Malfunction code, and Action Taken Codes F, K, L, P, R or Z.

c. A Flight Phase is a pre-defined portion of a flight. A flight is partitioned into nine phases in this model.

d. Flight Time begins with engine start-up and ends at engine shut-down.

e. A Hazardous Mode of operation is characterized by the fact that there has been a failure and the aircraft and crew exposed to danger. Whether the event will result in an accident, an incident, or merely the exposure to danger is dependent upon many factors which are beyond the scope of this model.

f. The Link Dependency of function A on function B is the probability that loss of B will result in loss of A.

g. A provisory Factor is a quantified allowance for a condition outside the typical operating envelope of the aircraft, i.e., it is the probability that the condition exists in a given flight.

h. The Sensitivity of a Function is the conditional probability that, given the loss of the function, the aircraft will enter a hazardous mode.

i. The Sensitivity of a WUC is the conditional probability that, given the failure of the WUC, the aircraft will enter a hazardous mode.

After a feasibility study showed that the approach had potential, the method was developed by ARINC under contract to SA-ALC/MME between October 1967 and September 1968. The F-106 aircraft was used in the prototype.

Validation of FSPT by SA-ALC Engineering personnel was completed in July 1971. Twenty additional aircraft models were developed between January 1971 and September 1976. No aircraft have been added since that time.

Though FSPT has not been utilized, recent events at HQ AFLC have created new interest in the program. Presently there is a command-wide effort to update existing aircraft models. New models have been approved, and the possibility of extending the method to helicopters is under study.

DESCRIPTION:

Let "F" designate the event that a particular WUC has failed and let "H" designate the event that the aircraft is in a hazardous mode. Define C, the criticality of a WUC, as follows:

$$C = P(F \cap H),$$

where $P(F \cap H) = P(H/F) \times P(F)$ is the probability of H given F and P(F) is the probability of F. This equation means that the probability that a particular WUC will cause the aircraft to enter a hazardous mode (WUC criticality) is the product of two probabilities. The first of these is the probability that the aircraft will be unsafe if the WUC fails (sensitivity) and the second is the probability that the WUC will fail.

The probability of failure can be estimated with sufficient accuracy from AFM 66-1 data using the exponential distribution and defining a failure as in paragraph b, above.

The values of WUC sensitivities are calculated with a computer assisted FMEA. This is accomplished by developing a success tree of functions of the aircraft, estimating the probability of each junction, and coding the tree for computer tracing. The computer is then programmed to trace each branch in the tree, compiling the probabilities as it traces.

The following is a brief description of the method of developing a probability tree. An outline of four basic steps is followed by a discussion of three significant factors. A more detailed description is given in *AFLCR 400-49, Chapter 6.*

The first task in developing a tree is to identify the functions performed by the aircraft and how these functions are interrelated. This function analysis is performed utilizing information from the maintenance manuals. (See Table 1 for a list of the major functions used in FSPT.)

TABLE 1. MAJOR FUNCTIONS

FUNCTION	DESCRIPTION
Propulsion	Engine, Engine Accessories, Fuel System
Communications/Navigation	UHF, ILS, TACAN, TDDL, ADF
Information and Display	Fire and Overheat Detection, Engine Instruments, Fuel Quantity Indicating, Power System Indicating, ARDC Instrument.
Environment Control	Engine and Surface Anti-Ice, Air Conditioning and Pressurization, Oxygen Supply, Lighting.
Flight Control	Attitude Control, CG Control, AFCS, Speed Brakes.
Ground Control	Nose wheel steering, wheel brakes, drag chute tail hook.
Landing Gear	Landing Gear and Landing Gear Extension.
Mission Support	Equipment related to flight safety but peculiar to the mission of the aircraft
Utilities*	Electrical, hydraulic, and pneumatic power supplies.

* Utilities is not a true function, but it is convenient to treat it as such in FSPT modeling. Utilities is called a secondary function to distinguish it from a true or primary function.

The second step is to construct functional block diagrams of each of the major functions. These diagrams define the relationships between the function and its sub-functions as well as the intra-relationship between sub-functions. For each sub-function the relationships with its sub-sub-function are defined, identifying successively lower level sub-functions continues until an input from a component (WUC) or from the the air crew is reached. Thus, the success tree is developed with each path through the tree beginning at a major function and ending at either a WUC or an air crew input requirement.

The third task in developing a probability tree is the assessment of the sensitivity of the major function. The actual numerical values are proporional rather than absolute. The value will be the analyst's best estimate of the likelihood that the aircraft will enter a hazardous mode if the function is not present.

Although a great deal of information exists on accident cause, little is available from which to make the sensitivity assessment. Team review and negotiation of sensitivity assignment is the mechanism by which the value becomes sufficiently objective for use within the model. The review team consists of a safety engineer, a system reliability engineer, the appropriate skill engineers and a pilot with experience in the aircraft being modeled.

The fourth step is link dependency assessment. Link dependency is the probability that the loss of a function will cause the loss of the next higher function which is dependent upon it. The assignment of link dependence requires only a knowledge of the system operation because it is concerned only with function levels below those assigned a function sensitivity. In assessing the link dependency of hydraulic pressurization for instance, the analyst makes no evaluation of the impact on flight safety of the loss of the function. Instead he is only interested in an individual link. The eventual evaluation

will be made by the computer which will trace paths, multiplying each successive link dependency times the sensitivity of the top level function to arrive at a sensitivity for each WUC.

Finally, the task is completed by coding the function in the diagram for computer identification.

The function of some components, as well as the importance of the loss of a function, is not constant throughout a flight. The rudder pedals, for an example of the former, are also brake pedals during landing and taxi. An example of the latter, a loss of propulsion, is more serious when the aircraft is airborne than when on the ground and most serious during lift-off and climb. To deal with the problems of changing roles, the mission is divided into nine phases. These are start-up and taxi out, take-off, ascend, cruise-out, perform mission, cruise-in, descend, land, and taxi in and shut-down.

The significance of certain major functions and some lower ones is dependent on external influences. For example, a windshield anti-ice system has a high sensitivity during landing under icing conditions but has no effect on safety on a warm, dry day. For such functions, the procedure used is to assign the worst case sensitivity which would be modified by a provisory factor. In general, provisory factors represent the probability of the existence of external conditions influencing the sensitivity of the function. Table 2 is a list of provisory factors used.

The terms "parallel" and "series" as used in reliability block diagramming lose their literality when applied to function block diagrams. That is, the blocks of one level will be in a row regardless of whether series or parallel. To avoid confusion, "redundant" and "required" are used.

Redundancy can be either active or stand-by. However, from the point of view of flight safety, situations involving true active redundance are rare. Careful analysis of apparent cases will inevitably reveal that failure of one of the actively-redundant units will degrade safety.

TABLE 2. PROVISORY FACTORS

Code	Description
A	Icing Conditions
B	Adverse Altitude and Speed Combination
C	Short Runway
D	Night Operation
E	IFR Conditions
F	Supersonic Flight
G	Rain
H	Solo Flight
I	Loss of function for which indicator is provided (Applies to Table I, Information & Display Function only)
K	Normal System Failed
T	Flame-out
X	Fire
Y	Cold Weather
2	One of three available units is required
3	Two of three available unit is required
4	One of four available unit is required
5	Two of four available unit is required
6	Three of four available units is required
7	One of five available units is required
8	Four of eight available units is required
9	Four of eight available units are required and failures are not necessarily independent.

Assignment of link dependence values to redundant sub-functions utilizes either provisory factor K or one of the numeric codes (see Table 2). The value assigned to the stand-by unit is the dependency of the higher level function on receiving an output from either unit. The value of the primary unit is the probability that the stand-by unit will fail to produce or will degrade the required function.

EXAMPLE:

Consider the Environment Control function of the T-37. This function can be divided into two sub-functions, External Environment Control and Internal Environment Control (see Figure 1). Ignore the External Environment Control Sub-function for simplicity in the example. The Internal Environment Control can be divided into Defog, Oxygen Supply, and Air Conditioning and Pressurization. The latter of these requires a mode of selection, an air distribution system, and either conditioned or ram air. Conditioned Air requires both cold air and hot air and mixture control as well. And, finally, Mixture Control can be either automatic or manual. Other system inputs required are Engine Bleed Air to Defog, Cold Air and Hot Air; 28 volt DC power to Automatic and Manual Controls; and 120 volt AC power to Automatic Control.

Notice that there are two places where redundance occurs in this example, in the requirements of Air Conditioning and Pressurization and of Mixture Control. In all other cases, the total number input is required.

WUCs are usually not included on a function block diagram because they clutter, making the diagram difficult to read. WUCs can be tabulated on a separate list. Such a list for the example would include Ram Air Ducts under Ram Air, Piccolo Tube under Distribution, Mixing Muff under Mixture Control, and many other (see Table 3).

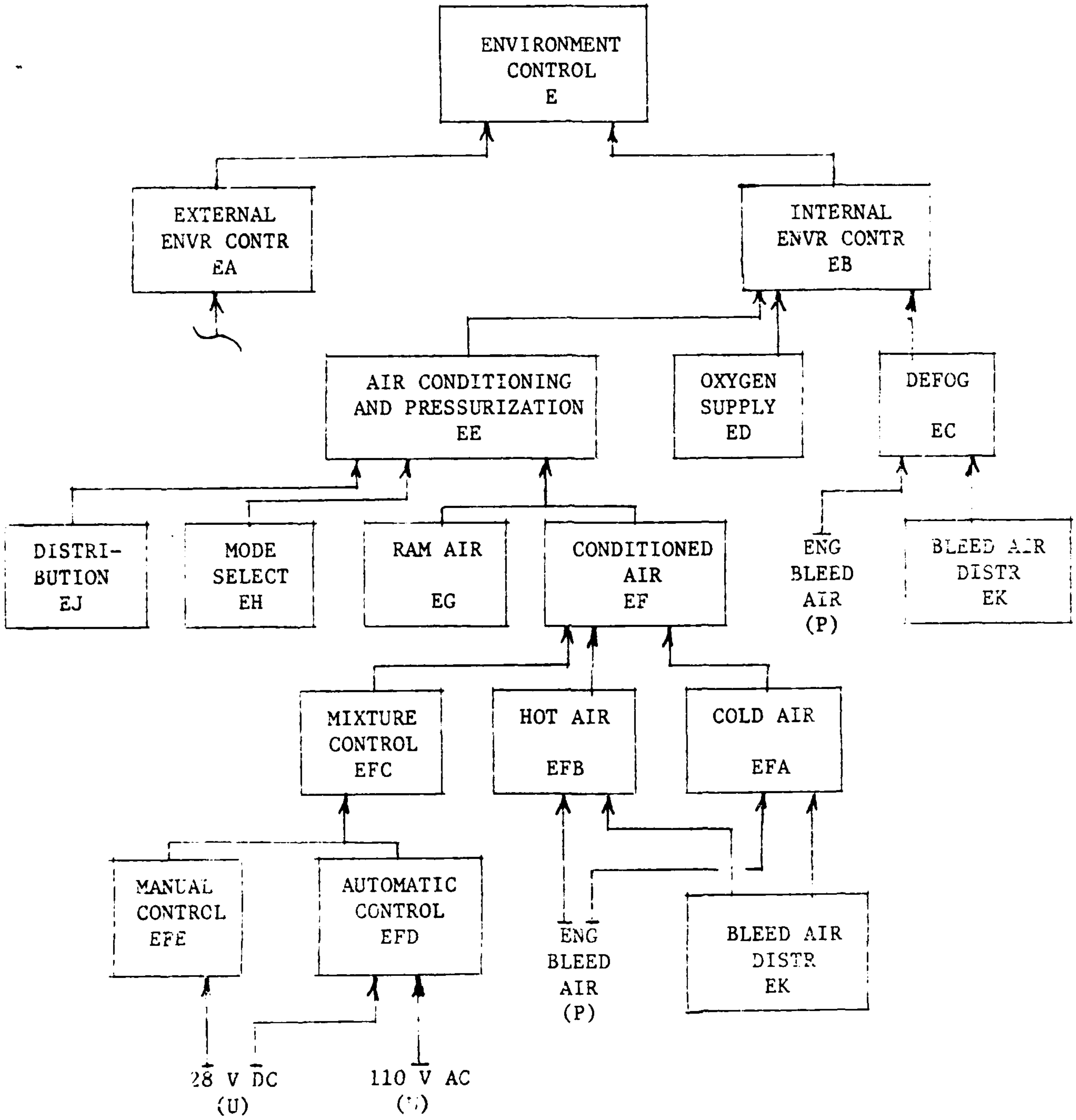


Figure 1 Function Diagram

TABLE 3. WUC LIST

WUC		ALPHA CODE	DEPENDENT FUNCTION
41145	Defog Duct	ECA	EC
41117	Defrost Valve	ECB	EC
41143	Diluter	ECC	EC
14421	Heater Exchanger	EFK	EFA
4112A	Refrigeration Unit	FFL	EFA
41142	Mixing Muff	EFG	EFC
41131	Modulating Valve	EFH	EFC
4113A	Temperature Control Switch	EFJ	EFC
41135	Thermoresistor	EFM	EFD
41136	Temperature Control	EFN	EFD
41137	Manual Selector	EFP	EFE
41123	Ram Air Valve	EGA	EG
41144	Piccolo Tube	EJA	EJ
41122	Water Separator	EJB	EJ
41115	Bleed Air Shutoff	EKA	EK
41114	Check Valve, LH	EKB	EK
41114	Check Valve, RH	EKC	EK

PLANNING, PROGRAMMING & BUDGETING SYSTEM

PLANNING

- DETERMINE TOTAL FORCES REQUIRED TO COUNTER THREAT
- ESTABLISH BENCHMARK TO
  - HIGHLIGHT CRITICAL NEEDS
  - MEASURE RISKS
  - GUIDE RESOURCE DECISIONS

PROGRAMMING

- MATCH AVAILABLE $ WITH MOST CRITICAL NEEDS
- DEVELOP 5-YEAR RESOURCE PROPOSAL

BUDGETING

- FINAL COST APPROVED PROGRAMS
- PREPARE & SUBMIT DETAILED BUDGET
- ENACT & EXECUTE

DEFENSE RESOURCES BOARD

<u>FUNCTIONS</u>

- DOD BOARD OF DIRECTORS
- REVIEWS DEFENSE GUIDANCE
- CONDUCTS PROGRAM AND BUDGET REVIEWS
- INTEGRATES ACQUISITION PROCESS WITH PPBS

<u>MEMBERSHIP</u>

- CHAIRMAN - DEPSECDEF
- EXEC SEC - EXEC ASST TO DEPSECDEF
- MEMBERS
  - CHAIRMAN, JCS
  - SECRETARY, AIR FORCE
  - SECRETARY, ARMY
  - SECRETARY, NAVY
  - USD (POLICY)
  - USD (RESEARCH & ENGINEERING)
  - ASD (COMPTROLLER)
  - ASD (DEVELOPMENT & SUPPORT)
  - ASD (HEALTH AFFAIRS)
  - ASD (INTERNATIONAL SECURITY AFFAIRS)
  - ASD (INTERNATIONAL SECURITY POLICY)
  - ASD (MANPOWER, RESERVE AFFAIRS & LOGISTICS)
  - DIR (PROGRAM ANALYSIS & EVALUATION)
  - ASSOC DIR/OFFICE OF MGT & BUDGET

NOTE: SERVICE CHIEFS ATTEND BY INVITATION

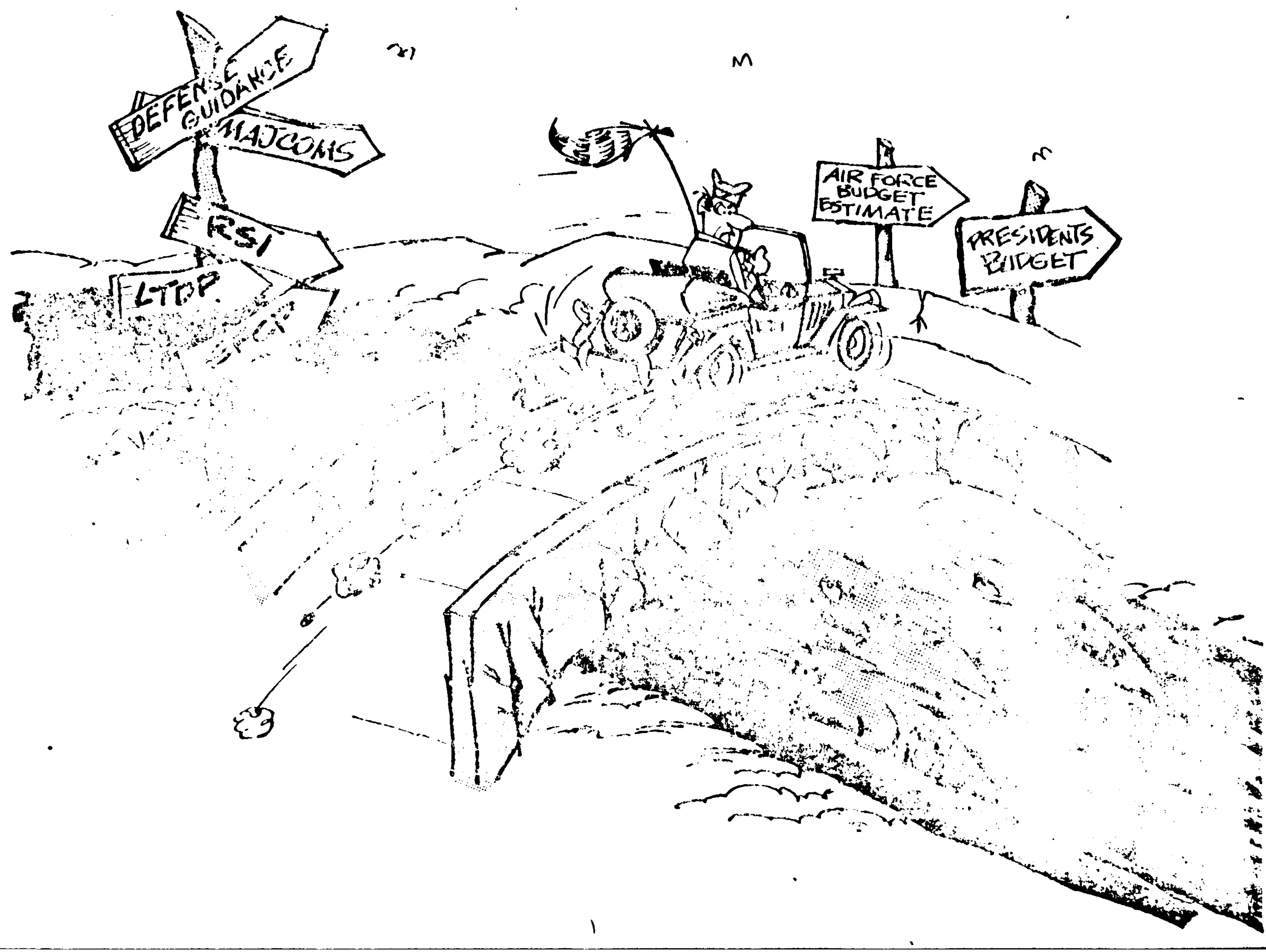
PPBS REVISIONS

- MANAGEMENT PHILOSOPHY
    - CENTRALIZED POLICY DIRECTION
    - DECENTRALIZED EXECUTION
    - PARTICIPATORY MANAGEMENT
    - ECONOMY & EFFICIENCY

PPBS

PLANNING PROGRAMMING BUDGETING SYSTEM

- DOD RESOURCE MANAGEMENT PROCESS
- IDENTIFIES MISSION NEEDS, MATCHES WITH RESOURCES, TRANSLATES INTO BUDGET PROPOSALS
- SECDEF CONTROLS PROCESS
  - INTERACTS WITH JCS AND SERVICES
  - PROVIDES INCREASINGLY RESTRICTIVE GUIDANCE/DECISIONS
    - POLICY GUIDANCE
    - FISCAL AND PROGRAM GUIDANCE
    - PROGRAM AND BUDGET DECISIONS
- DOD PORTION OF PRESIDENT's BUDGET


DEFENSE GUIDANCE
MAJCOMS
RSI
LTDP
AIR FORCE BUDGET ESTIMATE
PRESIDENTS BUDGET

PAGENTRY,

POUNDAGE AND

BULL

S___

PLANNING, PROGRAMMING, BUDGETING AND THE AIR FORCE

(BY MAJOR CAMPBELL)

the inflation rate that the aerospace industry and its subcontractors are experiencing, SA estimates that the total spares requirement may be understated by as much as $800 million in FY 81, $1.7 billion in FY 82, and $2.4 billion in FY 83. Less than 20% of the difference each year is due to computation changes unique to that year; over 80% is due to the compounding effect of unfunded carryover.

Despite this persistent underfunding, the Air Force has flown its peacetime training missions each year. At the same time, however, major commands have suffered higher than desired NMC rates, approximately 40-50% of which can be attributed to spares-related deficiencies. If the Studies and Analyses funding estimates for FYs 81-83 prove valid, NMC rates could exceed USAF estimates by 10-15%, as indicated in Figure 3. This chart focuses on first line tactical fighters, and relates funding for peacetime operating stocks (top half of chart) to NMC rates and, specifically, to that portion of NMC related to spares support (bottom half of chart). (Note the two year offset for lead time between the top scale and bottom scale.)

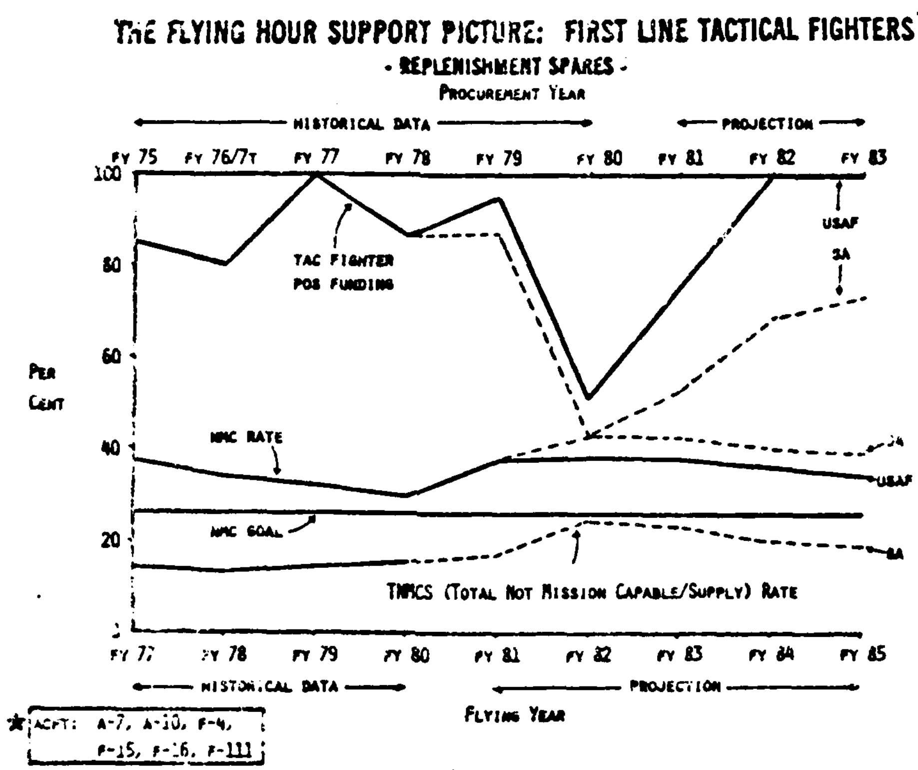


Fig. 3

To offset supply problems, the Air Force has had to cannibalize needed parts from out-of-commission aircraft, withdraw assets from WRM, move spares among bases, and speed the flow of reparable assets through depot maintenance cycles. These actions mask the seriousness of the supply shortfall, impose added work on maintenance personnel, and adversely affect warfighting sustainability. Further underfunding in the future will force continuation of these activities.

Funding shortfalls will continue until some method is developed to more accurately project requirements for POM funding. Breaking this first link in the problem cycle will greatly mitigate the effects of continued requirement growth, and will be a significant first step to terminating the unfunded carryover issue.

Of the $2 billion growth, approximately 65% ($1.3 billion) can be traced to changes in the computation data base. The remaining 35% was the result of an $800 million unfunded FY 79 requirement that carried over and escalated at each subsequent computation. The net result was a $1.5 billion carryover as of the September 1980 computation.

Figure 2 illustrates the funding dilemma. Because the Air Force did not receive a budget supplement in FY 80, adjustments resulted from internal reprogramming. However, from POM funding in December 1977 to the high point of reprogramming in January 1980, total funding only increased 9%. During the entire period, the overall funding percentage dropped from 54% to 24%, and $2.8 billion in unfunded requirements carried over in FY 81. (This carryover was 75% larger than the original POM requirement.)

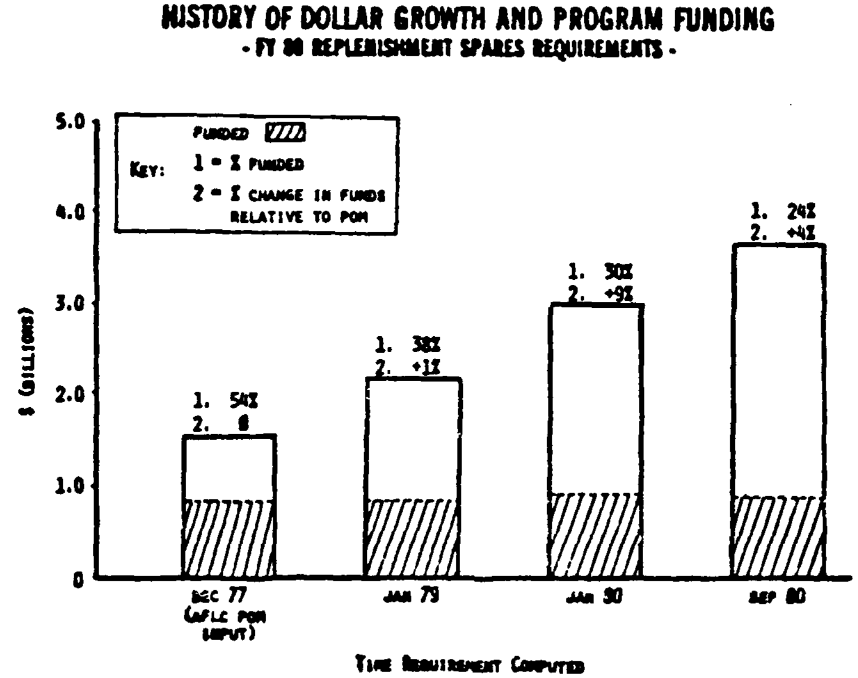


Fig. 2

Because of the three year programming cycle and continually changing requirements, AFLC is almost powerless to "catch up" under existing guidelines.

Near-term increases in the flying hour program (those which occur after AFLC has begun procurement) add to the spares shortfall problem. The mix of aircraft involved in such changes is important because flying costs vary considerably. Moreover, cutting hours for lower cost aircraft to offset added hours for higher cost aircraft will not solve the problem and results in the wrong mix of parts in the spares pipeline. To date, near-term flying hour changes have ranged from 2-5% of each year's program, with associated cost increases of 1-8% of the replenishment spares budget.

The significance of these changes lies in the carryover effect noted above. For example, changes in the FY 81 flying program would have cost approximately $86 million if they could have been accommodated in the FY 79 replenishment spares budget (assuming a two year procurement lead time for spares). However, the changes occured after the FY 81 and 82 budgets were completed. For the FY 81 and subsequent FY 82 changes will cost the Air Force almost $200 million in escalated carryover costs.

The problems identified in this paper will continue to plague the Air Force for the foreseeable future. AFLC has recently identified unfunded increases in FY 81 and 82 requirements that will carry over into FY 83. Studies and Analyses reevaluated the requirements for FYs 81-83. Based on already known inaccuracies in the computation data base and on

- The most current flying hour program projections are not always available when POS requirements are computed. Although the Air Staff provides flying hour data to AFLC quarterly, timing often lags the computation cycle, which may have to use data up to four months old.

- Base repair cycle and order and ship times fluctuate and may not accurately portray the condition of a system. For example, a suddenly decreasing repair cycle time may indicate that field units are short of assets and are expediting repair. Reducing procurement on the assumption that the shorter repair time will continue may not be valid.

- AFLC uses OMB/OSD-approved inflation indices to compute out-year costs. For several years, these indices have not reflected the actual state of the aerospace industry or its suppliers, and have been up to 50% low. Understating inflation compounds the inaccuracy introduced through non-current pricing.

Requirement projections in the replenishment spares programming cycle focus on three years: (i) the current or operational year, (ii) the budget year, and (iii) the POM or extended year. Since they are based on data and Air Force programs subject to constant change, requirement statements are, at best, valid only for the particular point in time at which they are made. POM requirement projections, which focus on the future, are the most inaccurate and subject to adjustment. During the past seven fiscal years, for example, final replenishment spares requirements have increased as much as 125% from the AFLC POM computation.

POM funding, based on these early requirement projections, has not been able to keep pace with such major growth. Once a POM funding level is established, it can seldom change more than a few percentage points without affecting other programs (unless the Air Force receives a budget supplement or amendment). As a result, a portion of each year's requirement is not funded and must be "carried over" to the next fiscal year, where the cost escalates due to inflation.

Figure 1 illustrates FY 80 requirements at four times, from the AFLC POM computation to the last time requirements were computed. The bars represent the total requirement, with shading to show the causes of growth: (i) changes in the original computation data, and (ii) escalated unfunded carryover. (The change in each bar includes the change from the previous bar; e.g., the "growth due to data base change" segment in bar 4 includes that from bars 2 and 3.)

HISTORY OF DOLLAR GROWTH

- FY 80 REPLENISHMENT SPARES REQUIREMENTS -

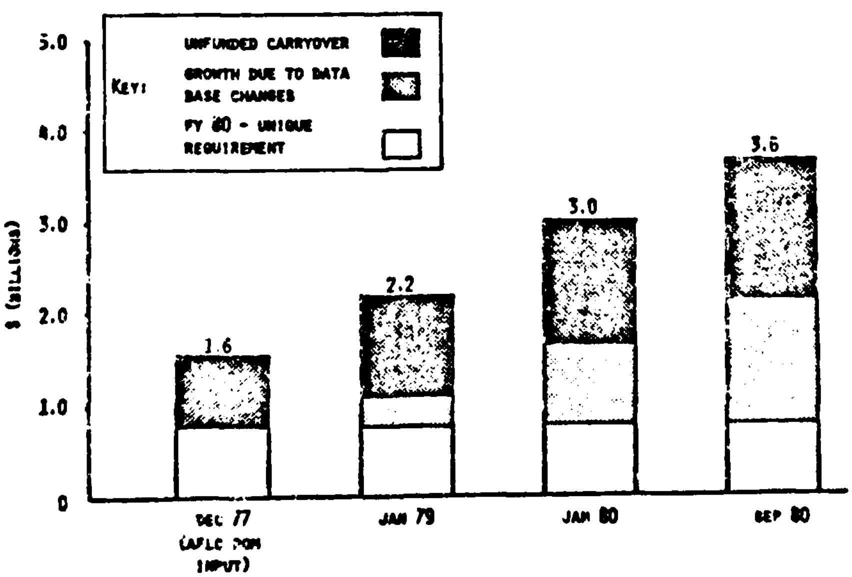


Fig 1

SABER PROVIDER-ALPHA

Programming for Aircraft Replenishment Spares: Problems and Prospects
May 1981

Replenishment spares are aircraft items which are (i) repaired when unserviceable, (ii) centrally managed and procured by AFLC, and (iii) normally have a unit cost of $1000 or more. They comprise over 91,000 stock numbers, had an inventory value of $8 billion in FY 80, and have accounted for 5-8% of the Air Force budget the past three years.

For at least the last decade, the Air Force has experienced deficits in its replenishment spares account, ranging from 38% in FY 77 to 76% in FY 80. The largest underfunding has occured in war reserve materiel (WRM), affecting war sustaining capability. But perhaps the most significant shortfall has been in peacetime operating stocks (POS) which support the flying training mission. The POS shortfall has been responsible in part for "not mission capable" (NMC) rates which have ranged from 15-46% higher than the 26% desired in the tactical fighter force. To offset this shortfall and fly its missions, the Air Force has had to take undesirable actions, including cannibalizing parts from aircraft, withdrawing assets from war reserves, and cycling assets more rapidly through the depot repair process (ultimately shortening their service life).

The origins of the procurement shortfall problem lie in the often inaccurate (because of its time sensitivity) and occasionally misleading data which form the basis for requirement projections and POM funding. These initial errors are compounded over time by a cumbersome programming system and by the effects of inflation. Recent adjustments in the programming process will not solve the problem, and in spite of a concerted effort to fully fund the replenishment spares portion of the FY 83-87 POM, the Air Force could face continued serious underfunding problems if our logistics planning and programming methods remain unchanged.

DISCUSSION

Replenishment spares requirements are primarily based on an extremely complex and time-consuming computation method known as the DØ 41 (Recoverable Consumption Item Requirement System). Its data base is very large, including failure and condemnation rates, item costs, on-hand serviceable and reparable assets, due-in assets, repair cycle times, projected peace and war flying programs, force structure and aircraft modification plans, order and ship times, etc. Unfortunately, much of this data is not current when used and some can be misleading, causing problems in requirement projection:

- Because the most current price of an item is often not available, AFLC programs for the unit cost it paid the last time it bought the item (plus inflation). This practice can result in substantial price understatement. After an almost nine year gap in purchases of C-5 engine spares, for example, AFLC found prices had increased an average of 189%.

- The computation process assumes that item failure and condemnation rates can be accurately forecast from past history. This is often not true with systems older than ten years because of system "fatigue" or with new systems for which a reliable field performance and repair history has not been established. Even "stable" systems suffer frequent unexpected problems.

Major Dale T. Pearson
Tactical Support Division

IV APPLICATIONS

Linear regression analysis is performed on twelve monthly criticality values each calendar quarter. Increasing trends obtained from these analyses are used to forecast impending unsafe situations. Of the many examples available, four were chosen to illustrate the usefulness of the method.

a. The F-106 rudder control valve and actuator assembly showed an increasing trend beginning in June 1978. This trend continued through December. A material related incident charged to the control valve occurred in February 1979.

b. In June 1979 the oxygen regulator which is common to the T-38, A-37 and T-37 showed increasing trends in each aircraft system. Five Class C mishaps occurred in a six-month period beginning January 1980.

c. An increasing trend began in December 1977 in the C-5 Central Air Data Computer. The criticality remained high through 1979. An incident not charged to material causes occurred in January 1980. Another incident which was material related occurred in March of the same year.

d. The T-38 fuel system P and D valve began an increasing trend in June 1980. In November two material caused incidents occurred.

TABLE 4. VALIDATION RESULTS

	Correlation Coefficient	Student "t" Statistic	Sample Size
WUC VS SYMPTOM			
System Summaries	0.91	8.51	17
Subsystem Summaries	0.58	6.32	79
5-Digit WUC	0.41	6.77	229
CRITICALITY VS MIPs			
System Summaries	0.70	3.83	17
Subsystem Summaries	0.27	2.54	83

III VALIDATION

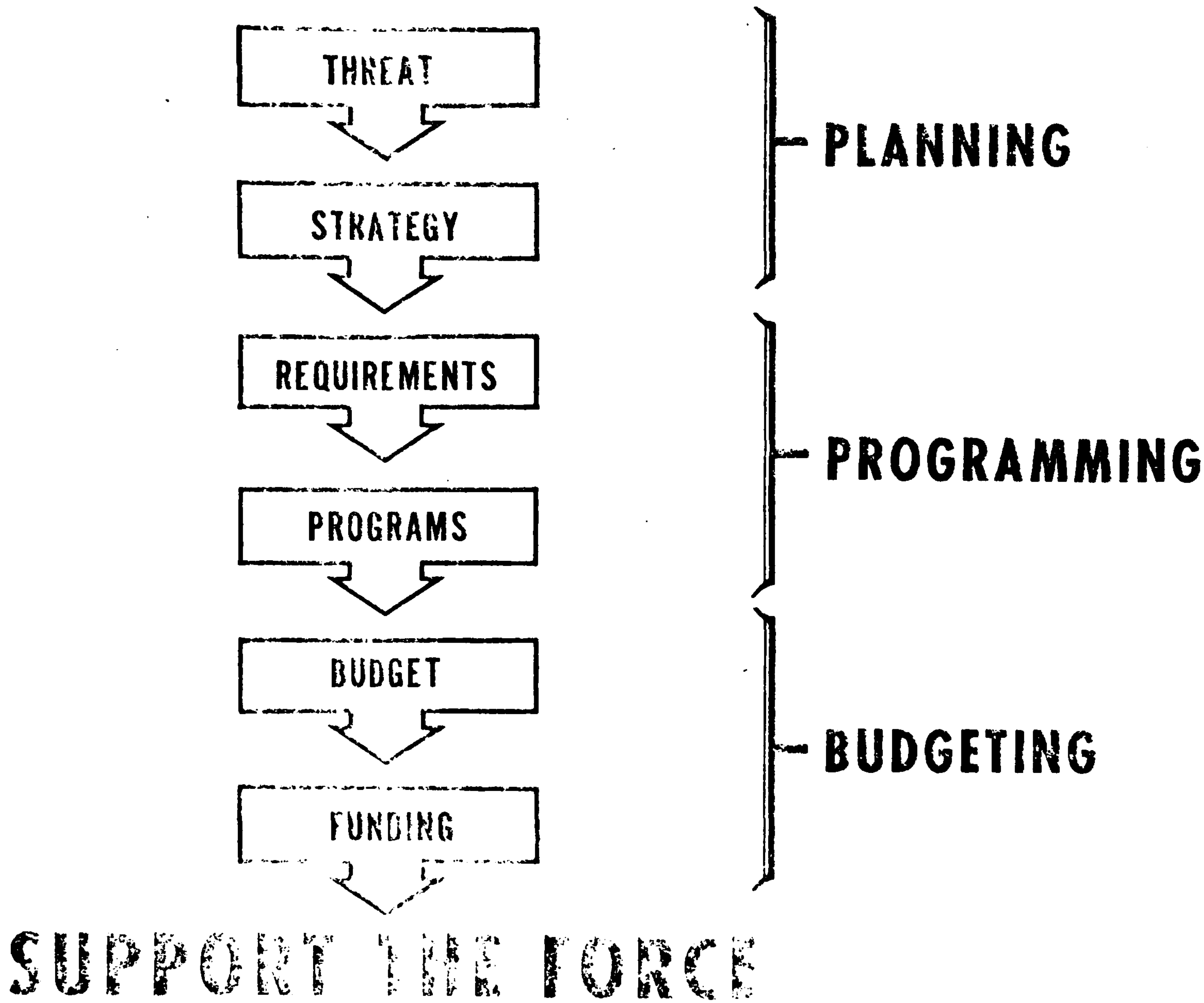
Because there were two data systems supporting the F-106 at the time FSPT was prototyped, two models that would identify problem areas were developed. The Criticality Model, which is described in Section II, uses input from AFM 66-1 data. The other, the State-Phase Model, is not presently in use. It was dependent on information from ADCOM Pilot Post-Flight Debriefings.

In the State-Phase Model, for each phase of flight, the pilot is assumed to be in one of three operational states: (1) Safe--No equipment malfunction symptom present; (2) Mode I Unsafe--Equipment malfunction present, but recovery or alternate mode of operation available; and (3) Mode II Unsafe--Disaster imminent. The probability of being in each of the three states during each phase of an average flight due to each of the pilot-reported symptoms were calculated. Various averages and rankings were performed on a monthly basis to portray recurring problems as indicated by the malfunction symptoms which were experienced in flight.

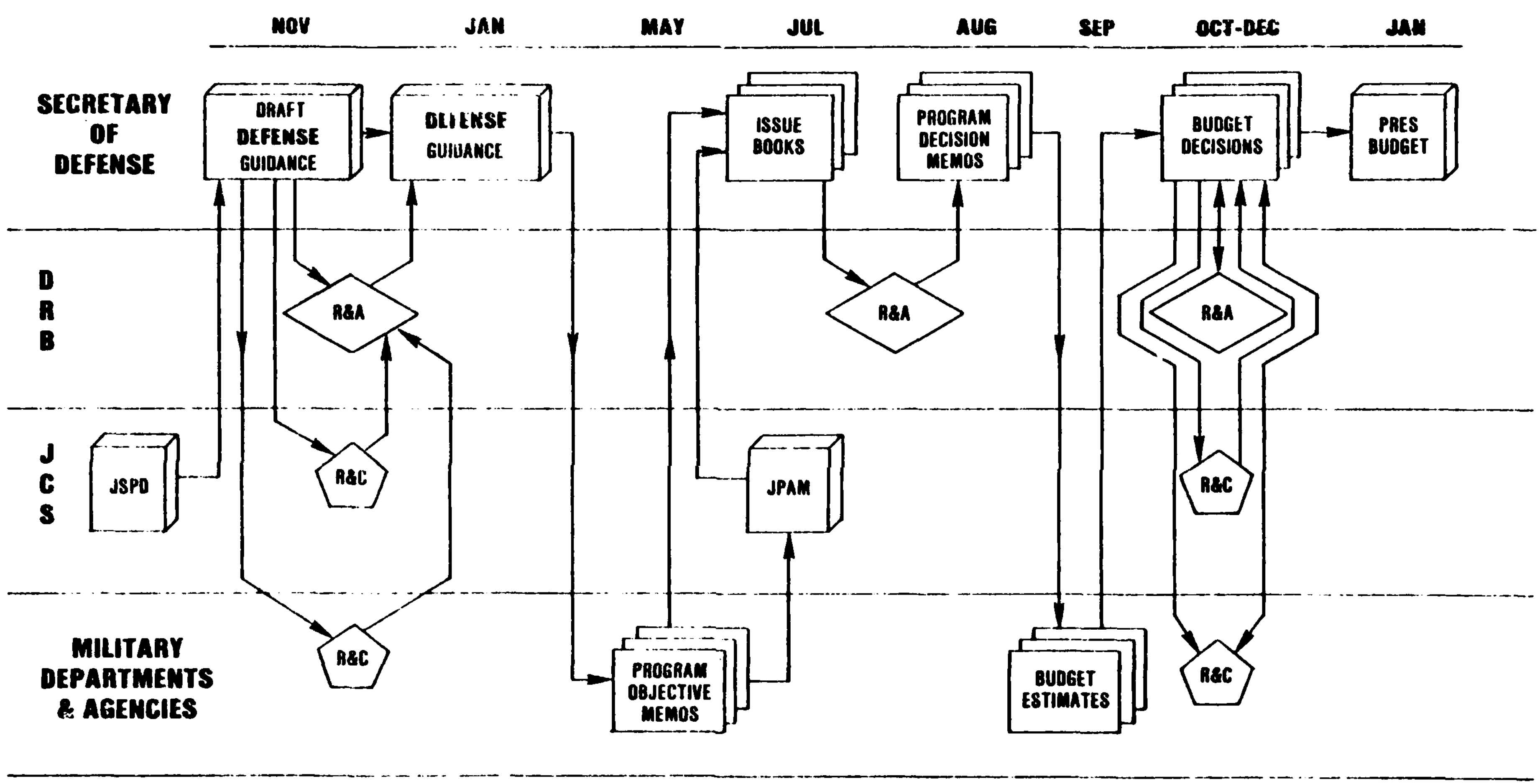
To compare the two models, symptom criticality was translated to WUC criticality. This was obtained by puting the symptom code in AFM 66-1 data reports in all F-106 pilot reported malfunctions. A given sumptom can contribute to more than one WUC failure and a given WUC failure can be indicated by any one of various symptoms. The proportion that each WUC contributed to each symptom was calculated. This proportion was used to allocate symptom criticality to the appropriate WUCs. Summing the apportioned symptom criticalities by WUC completed the translation.

The Pitman test for correlation was used to compare the outputs of the two models as well as to compare the criticality model to Material Improvement Projects (MIP). Data from a six-month period was used.

The test results, shown in Table 4, demonstrate a correlation between the models with 99.95% confidence and a correlation between model and MIPs with 99%.


THREAT
STRATEGY
REQUIREMENTS
PROGRAMS
BUDGET
FUNDING
PLANNING
PROGRAMMING
BUDGETING
SUPPORT THE FORCE

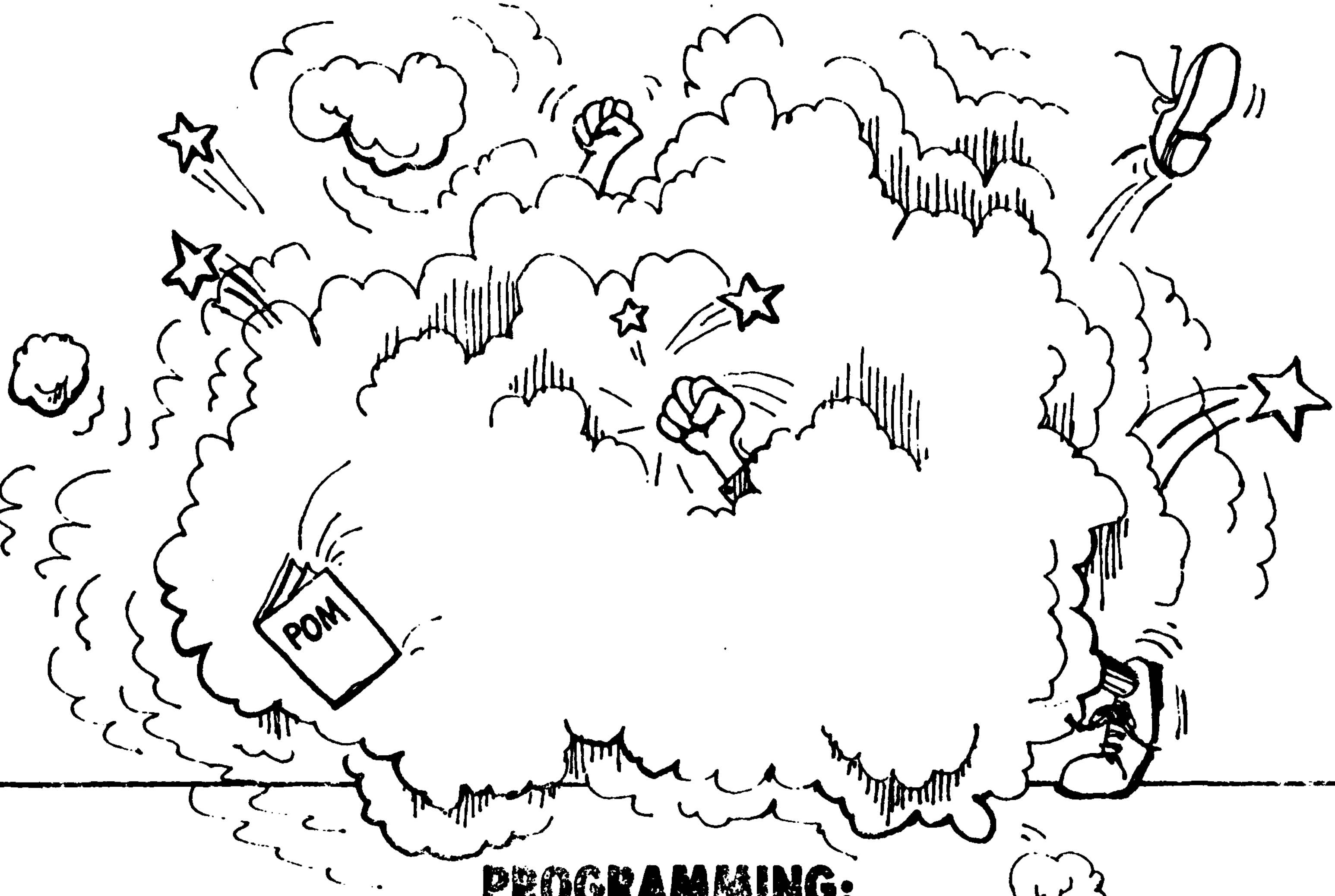
PLANNING PROGRAMMING BUDGETING



DRB = DEFENSE RESOURCES BOARD
JSPD = JOINT STRATEGIC PLANNING DOCUMENT
JPAM = JOINT PROGRAM ASSESSMENT MEMORANDUM

R&A = REVIEW AND ADJUST

R&C = REVIEW AND COMMENT



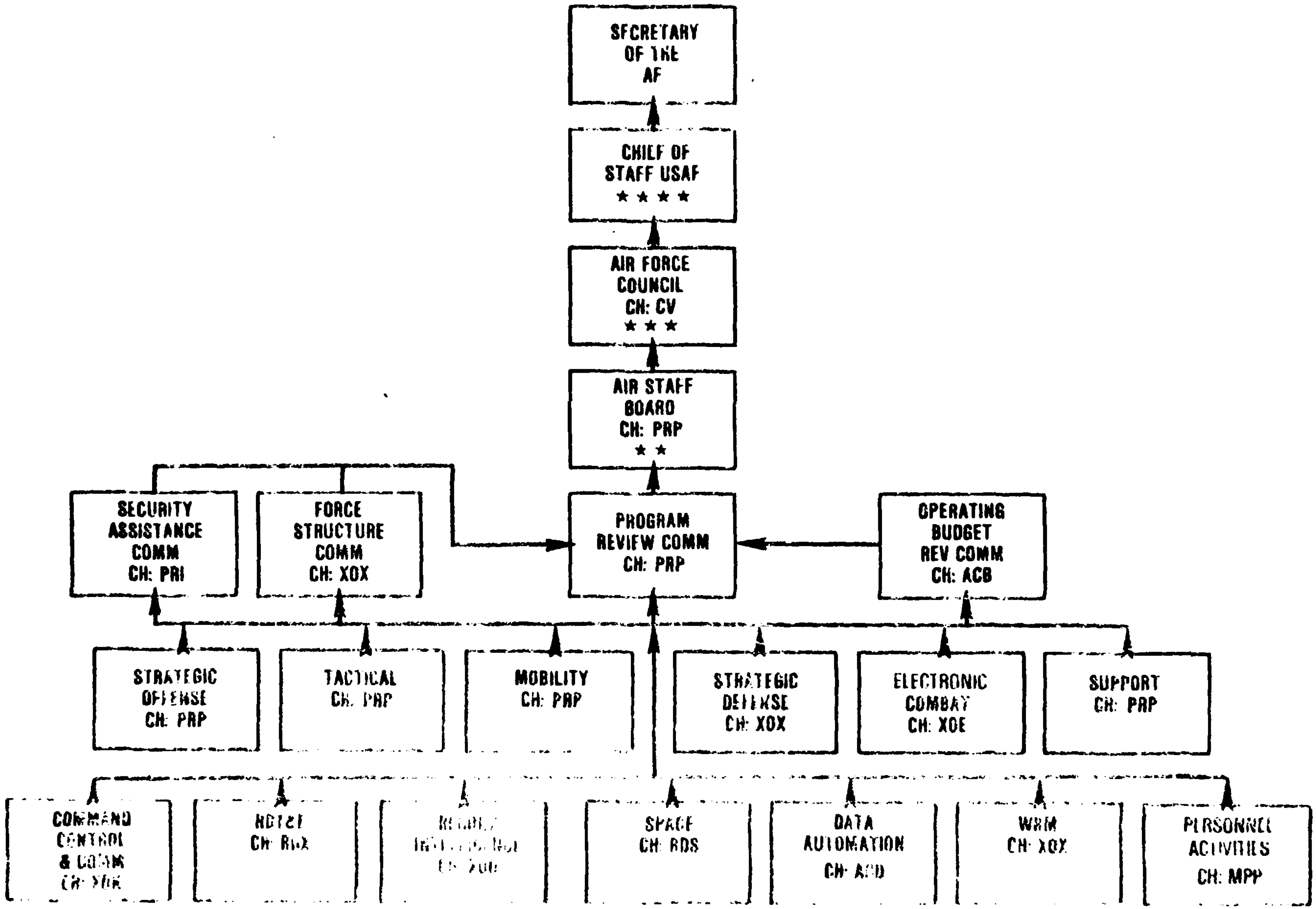
PROGRAMMING:

THE ART OF EQUITABLY DISTRIBUTING RESOURCES

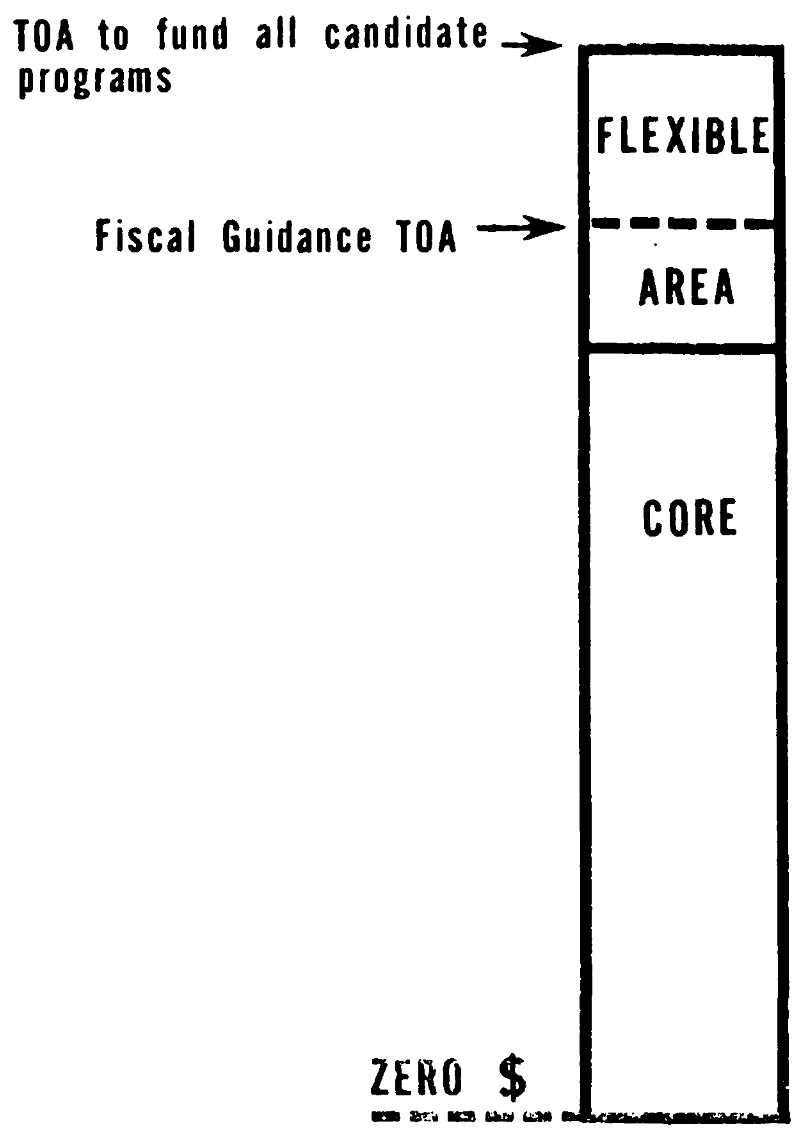
PROGRAM OBJECTIVE MEMORANDUM (POM)

- FIVE YEAR PROGRAM PROPOSAL
  - PRESIDENT'S BUDGET FYDP IS BASELINE
  - DIRECTION FROM OSD (DEFENSE GUIDANCE)
  - AIR FORCE PLANNING GUIDANCE
- REQUIRES SIX MONTHS TO BUILD
  - MAJCOMs, SOAs START EARLIER, PROVIDE INPUT
  - MAJCOMs, SOAs, AND FUNCTIONAL STAFF ADVOCATE CHANGES
  - BOARD STRUCTURE PROVIDES CORPORATE REVIEW/PROGRAM INTEGRATION
    - THIRTEEN PANELS
    - FOUR COMMITTEES
    - AIR STAFF BOARD (MAJCOM ATTENDANCE)
    - AIR FORCE COUNCIL (MAJCOM ATTENDANCE)
  - CHIEF AND SECRETARY APPROVE
- RESULT IS BALANCED PROGRAM
  - AMONG MISSION AREAS
  - BETWEEN READINESS AND MODERNIZATION
  - BETWEEN FORCE STRUCTURE AND SUPPORT
- "A" EXERCISES
  - VERIFY PRICING
  - UPDATE FYDP DATA BASE

AIR FORCE STRUCTURE FOR PROGRAM DEVELOPMENT



BUILDING THE POM



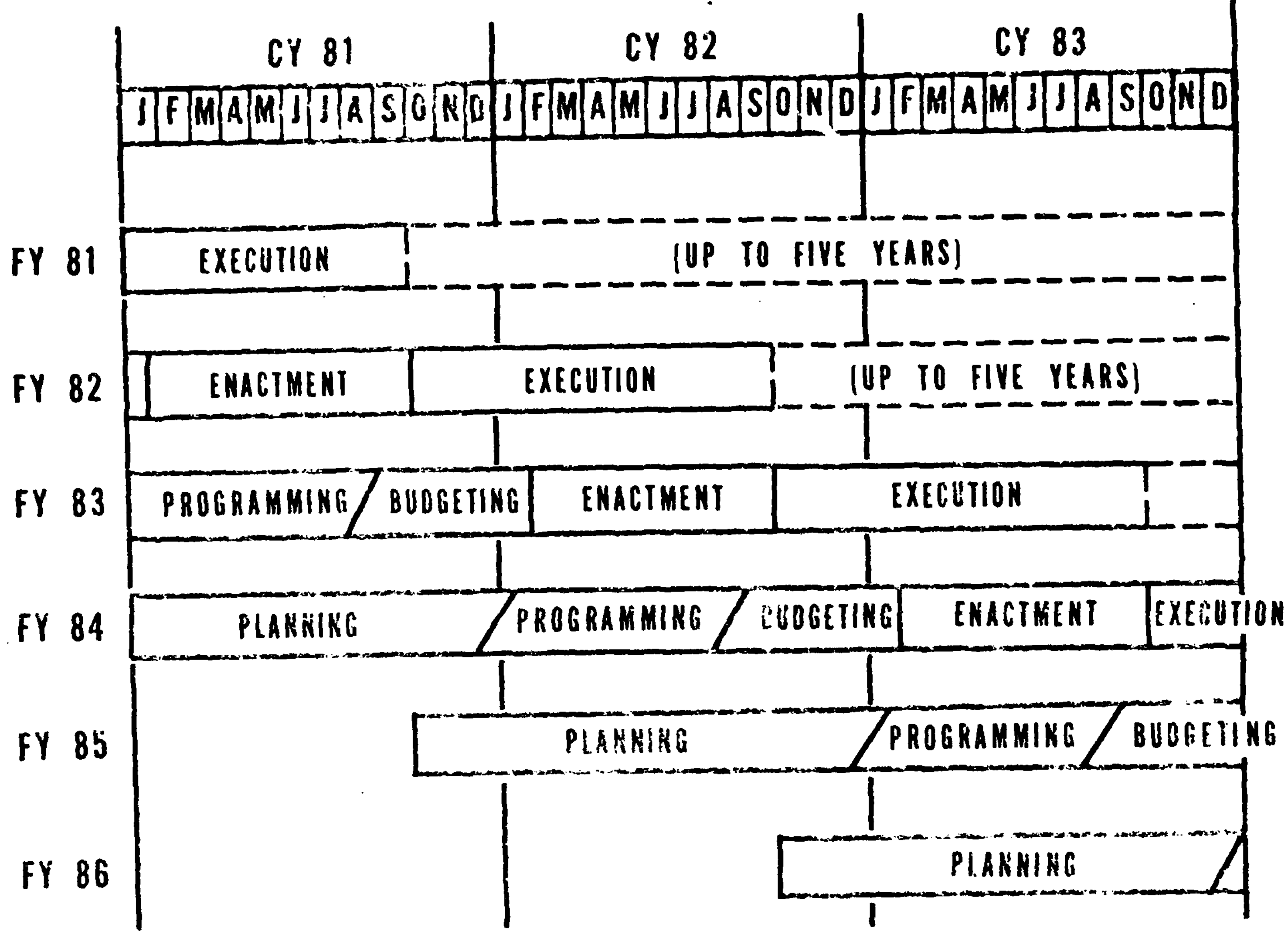
"FLEXIBLE AREA" Programs

- Force Growth Procurement
- Modernization Procurement
- Increased levels of:
  - Readiness, Sustainability
  - Research and Development

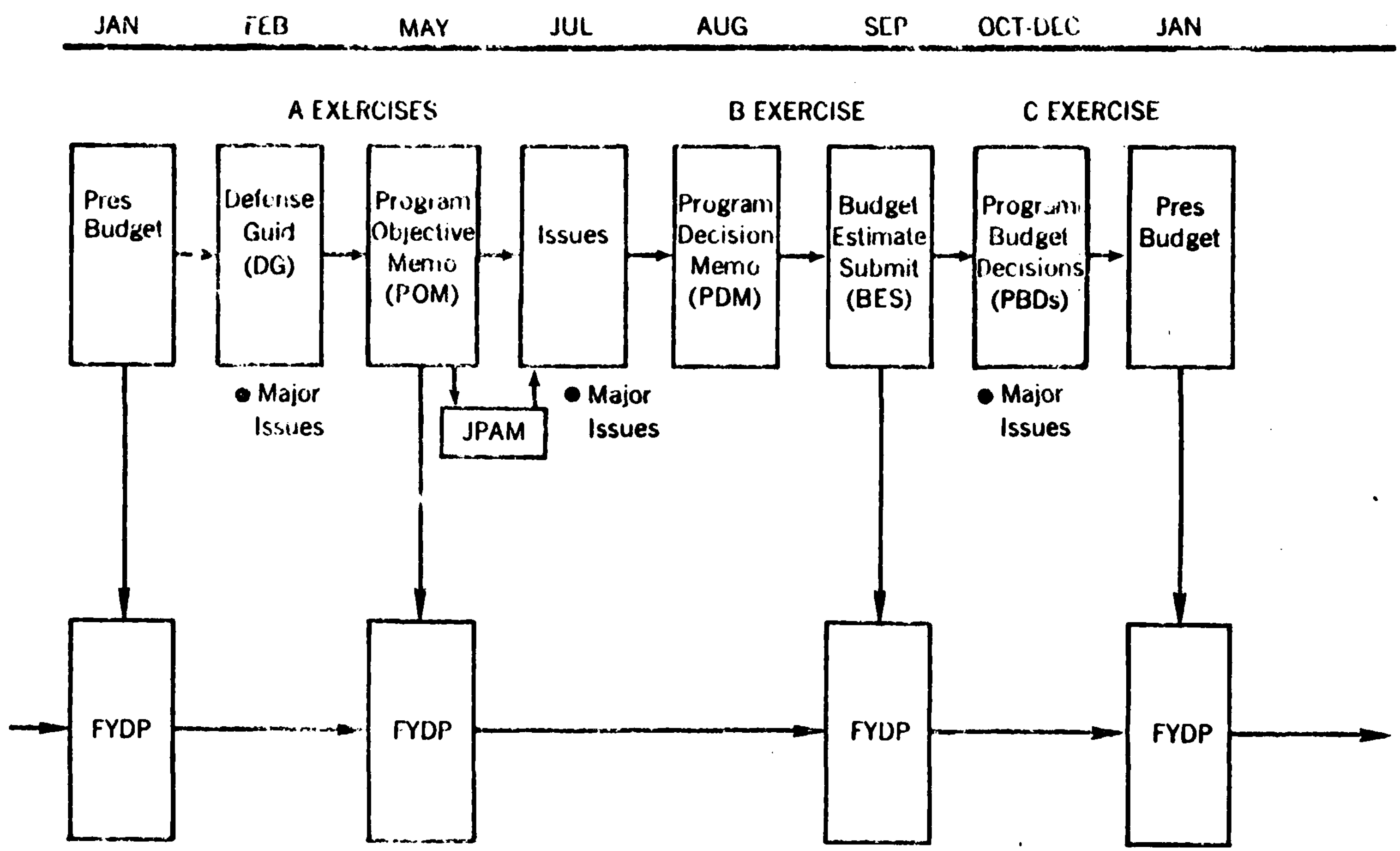
"CORE" Programs

- Peacetime Operations/Training
- Essential levels of:
  - Readiness, Sustainability
  - Research and Development
- Directed Programs
  - Intelligence
  - Strategic
  - Other
- Base Support
  - Base Structure
  - Personnel
  - Logistics
  - Other

CYCLE OVERLAP



PPBS AND THE PRESIDENT'S BUDGET



FYDP-Five Year Defense Program
JPAM-Joint Program Assessment Memo

DILEMMA

- HOW TO SUSTAIN AN AGING FORCE WHEN MODS, MILCON AND O&M AREN'T AS GLAMOROUS AS ANOTHER NEW F-15 ON THE RAMP

- HOW TO FORECAST AND FUND THE SUPPORTABILITY AND MAINTAINABILITY COSTS FOR THE NEW WEAPONS SYSTEMS

POSSIBLE SOLUTIONS

- BETTER ANALYSIS AND ASSESSMENT OF LOGISTICS REQUIREMENTS

- ARTICULATE THESE REQUIREMENTS AT THE MAJCOM/AIR STAFF LEVELS EARLY IN THE POM PROCESS

- BE PREPARED TO BETTER DEFEND THOSE LARGE CENTRALLY MANAGED "POTS": DPEM, STOCK FUND, MUNITIONS, ETC.

Where Do We Go From Here?

PART II

LT COL JOSEPH M. CAMPBELL

LOGCAS PLANNING COMMITTEE

HQUSAF/LEX - CHAIRMAN

HQUSAF/LEY	HQTAC/LG
HQUSAF/XOOI	HQSAC/LG
HQAFLC/LOR	HQMAC/LG
HQAFLC/XRP	HQAFSC/SD
HQAFLC/XRS	HQDLA-Z
HQAFLC/AQ	AFCOLR
AFLMC	

TASK

BUILD A PLAN

DESIGN A MANAGEMENT STRUCTURE

DEVELOP A GOVERNING REGULATION

LOGCAS

PLAN

THE PLAN

- ESTABLISH THE GOAL
- DETERMINE OBJECTIVES
- ENUMERATE STRATEGIES
  - MAJCOM INPUTS
- INTEGRATION OF PLANS
- PLAN MANAGEMENT

SECTION VI - ADDRESSES

This section includes transcripts of the invited speakers' remarks. They are included here in the order in which they occurred during the symposium.

VI-1. Opening Address: Lt Gen Richard E. Merkling, Vice Commander, AFLC

VI-13. After Dinner Speaker: Dr. Edwin Stear, Chief Scientist of the Air Force.

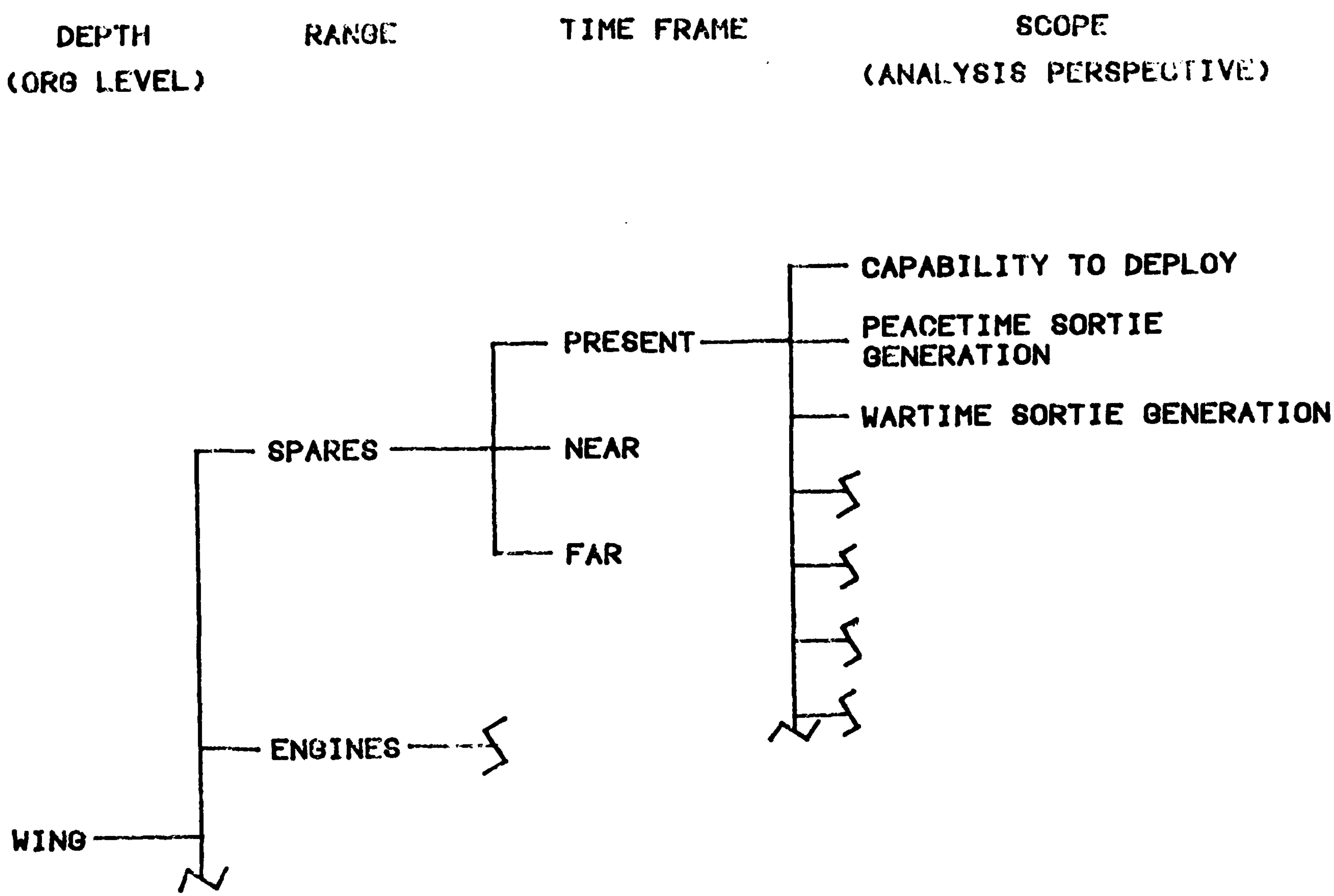
VI-24. Closing Remarks: Maj Gen Leo Marquez, Commander, Ogden Air Logistics Center

MANAGEMENT STRUCTURE

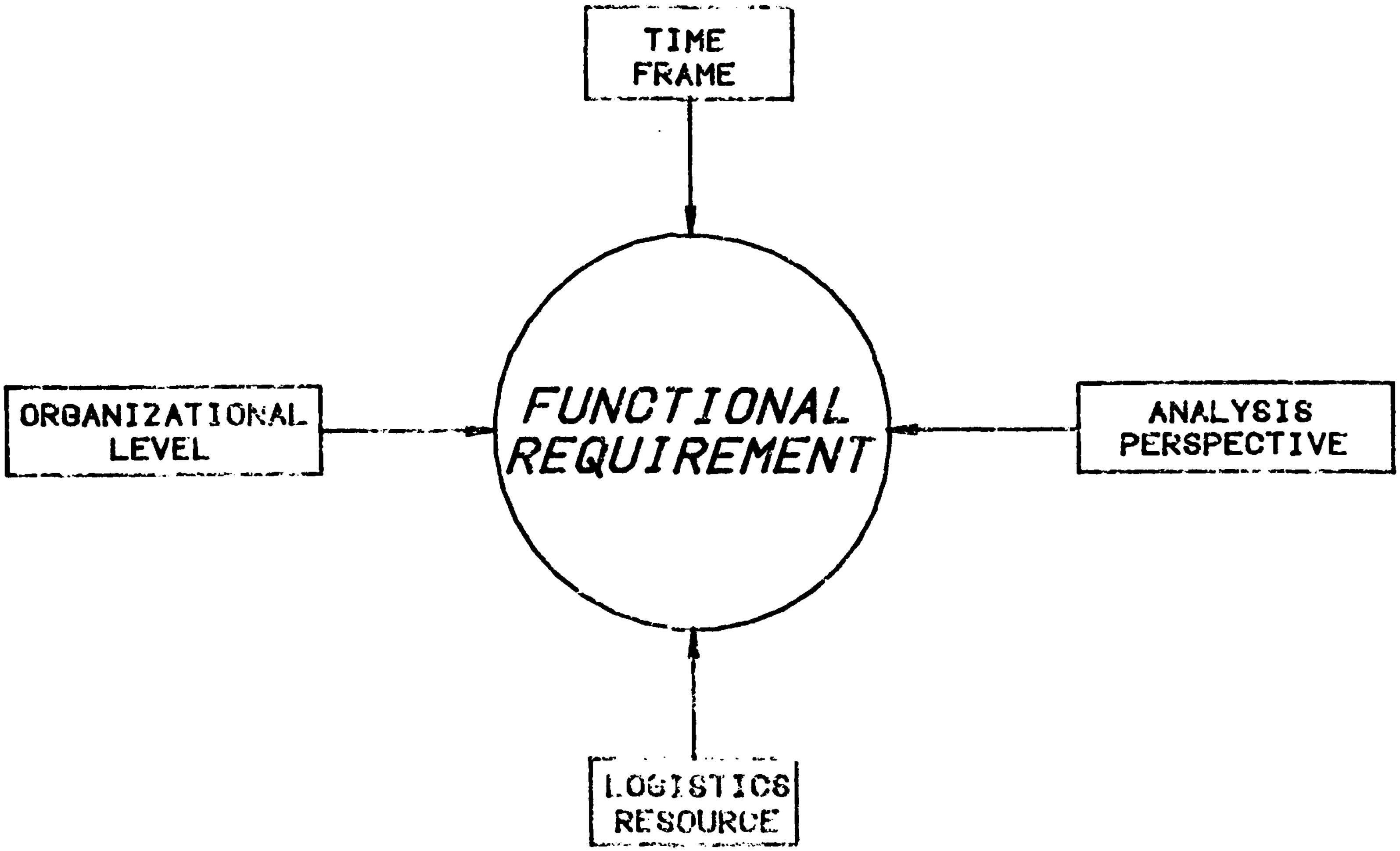
HQUSAF/LEXY (LOG CONCEPTS DIVISION) - OPR

AFCOLR (COORD OFFICE FOR LOG RSCH) - OCR

- CENTRAL POINT FOR AIR FORCE REPORTING
- PERFORM LITERATURE SEARCH AND PROVIDE BIBLIOGRAPHY
- ROUTE PROPOSALS
- MONITOR PLAN
  - COMMAND ACTIONS
  - DETERMINE APPLICABILITY


DEPTH
(ORG LEVEL)
RANGE
TIME FRAME
SCOPE
(ANALYSIS PERSPECTIVE)
CAPABILITY TO DEPLOY
PEACETIME SORTIE GENERATION
WARTIME SORTIE GENERATION
PRESENT
NEAR
FAR
SPARES
ENGINES
WING

FUNCTIONAL REQUIREMENTS DEFINITION



STRATEGIES (CONT'D)

- FORM A LOGCAS STEERING GROUP

STRATEGIES (CONT'D)

- ALL LOGCAS MODELS INCLUDED UNDER PLAN
- DICTIONARY OF TERMINOLOGY
- BIBLIOGRAPHY OF LOGCAS ACTIVITIES
- BIBLIOGRAPHY OF DATA BASES AND SOURCES
- DEFINE DESIRED MODEL INTERRELATIONSHIPS
- REDUCE DUPLICATION
- ENCOURAGE COMMUNICATION
- CONTINUE "LOGCAS XX" AS A FORUM
- REQUIRE AN ANNUAL REPORT FROM MAJCOMS ON PROGRESS

STRATEGIES

- PROVIDE GUIDELINES AND REQUIREMENTS FOR LOGCAS MODELS
  - MEANINGFUL MEASURES OF MERIT
  - DESIGN MODELS WITH USERS IN MIND
  - CONSIDER TIME VALUE OF RESOURCES
  - USE STANDARD DATA BASES
  - CAPABILITY FOR AUTO-UPDATING OF DATA
  - PROVIDE AUTO-SENSORS AND FLAGGING
  - STANDARDIZED DOCUMENTATION
  - TAKE STEPS TO VERIFY AND VALIDATE

OBJECTIVES

- PROMOTE THE USE OF LOGCAS MODELS BY AND ENHANCE THE CAPABILITY OF MANAGEMENT
- DEVELOP AN INTEGRATED SET OF MODELS
- DEVISE MEANINGFUL MEASURES OF MERIT
- INSURE LOGCAS MODELS MAINTAIN A PROPER RELATIONSHIP WITH THE REQUIREMENTS PROCESS
- PROMOTE MAJCOM PARTICIPATION
- ENCOURAGE AND FACILITATE THE EXCHANGE OF IDEAS
- CREATE AN EFFECTIVE MANAGEMENT STRUCTURE

PHASES IN THE LIFE OF AN AIR FORCE MISSION

PLANNING

PROGRAMMING

ACQUISITION

PEACETIME OPERATION

GENERATION

EMPLOYMENT

RECONSTITUTION

FOUR DIMENSIONS OF LOGCAS

RANGE	- THE VARIETY OF RESOURCES
DEPTH	- THE LEVEL OF FOCAS
TIME FRAME	- CHRONOLOGICAL POSITION
SCOPE	- PHASE OF MISSION

DEFINITIONS

MILITARY CAPABILITY IS THE ABILITY TO ACHIEVE A SPECIFIED WARTIME OBJECTIVE (E.G., WIN A WAR OR BATTLE, DESTROY A TARGET SET). IT HAS FOUR COMPONENTS:

- FORCE STRUCTURE
- MODERNIZATION
- READINESS
- SUSTAINABILITY

A FORCE OR UNIT CAN BE 100% READY (E.G., ALL EQUIPMENT "UP", ALL PERSONNEL TRAINED) AND STILL NOT PREVAIL AGAINST AN ENEMY DUE TO A DEFICIENCY IN ONE OF THE OTHER COMPONENTS OF MILITARY CAPABILITY.

DEFINITIONS

- READINESS: ABILITY OF FORCES, UNITS, WEAPON SYSTEMS, OR EQUIPMENTS TO DELIVER THE OUTPUTS FOR WHICH THEY WERE DESIGNED (INCLUDES THE ABILITY TO DEPLOY AND EMPLOY WITHOUT UNACCEPTABLE DELAYS).

- SUSTAINABILITY: THE "STAYING POWER" OF OUR FORCES, UNITS, WEAPON SYSTEMS, AND EQUIPMENTS, OFTEN MEASURED IN NUMBERS OF DAYS.

READINESS IS ESSENTIALLY A MEASURE OF PRE-D-DAY STATUS (EXTENDING AT MOST INTO INITIAL COMBAT OPERATIONS), WHILE SUSTAINABILITY IS A POST-D-DAY MEASURE. HENCE, WE OFTEN SPEAK OF PEACETIME READINESS, BUT WARTIME SUSTAINABILITY.

DEFINITIONS OF LOGCAS

- A PROCESS WHICH PROVIDES A MEASURE OF AN ACTIVITY'S ABILITY, EXPRESSED IN OPERATIONAL TERMS, TO COMPLETE OR PERFORM ITS MISSION(S), BASED UPON LOGISTICS RESOURCES.

- A MEASURE OF THE ABILITY OF A LOGISTICS RESOURCE, BASED UPON AVAILABLE AND/OR PROJECTED LEVELS, CONDITION, AND LOCATION, TO PERFORM A MISSION OR TASK.

THE GOAL

TO DEVELOP THE MEANS TO DETERMINE AIR FORCE CAPABILITY TO

- ACCOMPLISH THE DESIRED MISSIONS OF THE AIR FORCE
- IN TERMS OF READINESS AND SUSTAINABILITY
- FOR ALL LOGISTICS RESOURCES
- FROM CURRENT TO OUTYEARS.

SPEECH

FOR THE

LOGISTICS CAPABILITY ASSESSMENT SYMPOSIUM (LOGCAS) 82

DELIVERED AT THE

UNITED STATES AIR FORCE ACADEMY

15 MARCH 1982

LIEUTENANT GENERAL RICHARD E. MERKLING

VICE COMMANDER AIR FORCE LOGISTICS COMMAND

I'm pleased to have the opportunity to come and spend a few moments with you at this most important conference addressing modeling and the applications of modeling techniques to the problems of the Air Force International Logistics.

If I read your schedule correctly, you're going to address many different kinds of models, flow charts, diagrams, the mathematical equations that support those modules, the logical thought processes that go into the formulation of models and their construction. You perhaps will spend a few moments discussing basic types, whether they be Monte Carlo applications of pure analytical approaches to the math modeling technique.

I see where you will also have an opportunity to talk about some of the specific applications currently being worked or prepared for operation within AFLC. Such efforts include the opportunistic maintenance engine simulation model, the jet engine management simulator, simulation of removals for components and engines, Dyna-METRIC in terms of assessing the impact of reparable items on the overall system, the wartime assessment and requirements modeling that's being done, and perhaps several others that are extremely important for understanding our business and doing a better job of providing support to the United States Air Force.

Finally, perhaps you may touch on something that we cannot specifically learn from either textbooks or classroom activity, something we must develop over a period of time, something we must glean from experience. The formulations and acquisitions of that logical thought process which allows human beings to group physical phenomenon, environmental and mechanical characteristics, and random happenings in the various interactions of not only these parameters but the many others that go to make up our world and the way we operate in it. This thought process allows us to group and manipulate this data into either a mathematical or a simulation-type technique that, in turn, will allow us to see how certain things react in response to other controlled or uncontrolled inputs.

I believe it's obvious, that no matter how skilled one becomes in the systematic rote application of modeling technology in structuring such processes, these cannot be as effective as those done by a skilled modeler also familiar with the functional tasks, processes, and needs of the system and inputs that he is attempting to model.

Perhaps as you finish up your several days of activities in discussing these types of items, you may finally conclude that the bottom line need is to recognize and identify ways to convert the mental and implicit type modeling into more explicit mathematical models. This need is not only for detailed, but also for the much

more voluminous handling of the large amounts of data and the wide variety and numbers of items that go into making a support system that addresses an operation as wide and diverse as the United States Air Force.

Again, I think it would be somewhat presumptuous were I to attempt to give explicit instruction in how these many and varied tasks might be approached and solutions reached. However, what I might contribute to your conference is some small insight into the challenges I see before us, not only as a nation, but as an Air Force and as a logistics support command responsible for keeping that Air Force flying and ready t[illegible] fight. I am certain that all of you are generally familiar with the scope of our problem, but permit me to review just a few of our vital statistics.

As we closed 1981, the command had assigned slightly over 90,000 persons, of which approximately 81,000 were civilian. We were maintaining a USAF aircraft inventory of in excess of 9,100 aircraft, and these aircraft were flying or had flown about 2.6 million hours. The command was also overhauling, repairing, servicing in excess of 60,000 aircraft engines and approximately 2,900 USAF missiles. In accomplishing this overhaul, maintenance, and support activity, AFLC managed approximately 886,000 items and used in excess of 1.9 million items, the remainder being managed by DLA or another service. And from all sources, our item managers received requisitions for about 4.7 million parts. We performed periodic depot maintenance or analytical condition inspections on 1,049 aircraft and overhauled some 3,070 jet engines.

Why is this important, or what does this have to do with modeling? Only a moment's reflection, I believe, makes the answer obvious, particularly considering our limited fiscal capability. As we think of the process of acquisition, installation, usage, failure, removal, repair, restocking, finally perhaps reinstallation, and use again on all the many millions of reparable items that go to make up the machines, equipment, and weapon systems used by the United States Air Force, and as we think of our people maintaining that Air Force, it quickly becomes clear that people are doing the ordering. People are making the allocations of funds, the repair, the scheduling of transportation, the planning for the depot activities that must occur to support this closed-loop operation, ... these people need considerable help, if we're to operate on less than adequate funding.

That in turn means fewer than the optimum number of items in this supply and usage system and across a wide spectrum of flying hour usage and/or mission stress. I think all would agree that our people would do a much less professional job if forced to rely

totally on the historical experience that they were able to record and work with in a manual fashion and over a very limited spectrum of variables and input data. Admittedly, after an item has been in service for two years or more, DoD directives specify that our principal factor in determining buy quantities will be actual usage data adjusted for those various parameters which are admittedly variables, such as the changing flying time of units and MDS's of various weapon systems. While this historical data may remain relatively stable over the major portion of the mature life of the system, during that early period of introduction, and certainly in the final stage of our weapon system's life, these failure rates, usage quotients and the life change significantly, thereby taxing our every capability to forecast, predict, and understand what level of buy, repair, overhaul movement we need in the various areas of this program.

Only a few short years ago, the funding for all of our replacement items was in the eight to nine hundred million dollar range and during those same years, funding levels versus the calculated requirements ran in the 30 to 85 percent region so that we were always in a deficit buy position. During such periods of under-funding, it has been absolutely essential that the item managers and the procurement officers purchase the minimum number of items to keep the system operable so that the widest range of items could be covered. They were also forced to dedicate the maximum amount of money to those items which were most critical to that system's operation.

A real effort by the Air Force to fully fund our replen spares line during the last several years along with inflation has raised the dollar value of our replen spare account. For example, this year it exceeds two and a half billion dollars. While that does not say we are attempting to buy two and a half times as many spares and end items as during the period when our funding level was less than a billion dollars a year, we are taxed to handle much larger dollar values, and some increase in the number of spares we are purchasing.

The models I mentioned at the outset, the requirements calculations, wartime assessments, maintenance description and application modeling, jet engine and parts tracking systems all become key and essential in such an environment. These are some of the modeling requirements and needs of AFLC, and I certainly want to challenge you with them. However, over this entire requirement is laid the more demanding and driving need for a strong defense of our country.

In the next few moments, let me touch briefly on what I see as the driving functions in the logistics operations of today's

modern air forces, more particularly in the United States Air Force, with our reliance on high surge rates, massive involvement under certain scenario options and the existing economic and political factors.

First, I believe a thorough review needs to be undertaken with regard to our outyear and wartime planning models and assumptions. We must answer the following questions: Will we have sufficient investment items to satisfy a combat force under a given scenario? Have we established proper levels of bits and pieces necessary for the repair and return to service of these investment items? Finally, does the transportation system in handling procedures and techniques properly reflect what we, in fact, would do in an all-out situation of wartime activity? For example, in a recent (1982-86) program objective memorandum exercise, for a given costly part of an essential engine, we found that the majority of a stated requirement for 224 million dollars of parts was going, in large measure, to filling the pipeline and was not for attrition purposes. One must ask if we can really afford this kind of an investment for fill purposes.

And in the skills area, is it realistic to consider any help from U.S. industry in a time of real emergency, particularly in view of the short war scenarios that are generally accepted for any central European conflict? Could we hope to provide drawing or blueprints, instructions, and the like to civil industry, or would it be necessary to bring the skilled mechanics and technicians into our depots and place them in our operations?

Along this same line, is our depot capacity in terms of machines, processes and the like adequate for the tasks that we envisioned ahead? If not, what is the proper depot loading capacity criteria that should be used? OSD on certain of our exercises tends to measure us against an 85 percent usage rate. In other situations we find that the depot plant loading may be as low as 60-65 percent. What is the real number? Where can we or must we stand in supporting logistically the operational forces in the 1980 and beyond war? How many options can we afford to back? Nuclear, a major conventional conflict, a peripheral conflict in concert with one of the others, a third world conflict, or in a surrogate role supporting allies or friends without direct involvement.

In this regard, we must assess defense and employment strategies, and determine what changes are necessary. For example, what if the A-10 is employed in central Europe in an MOB/FOL type operation? What are the turnaround, repair, overhaul, and buy needs to satisfy a forward operating location main operating base concept? Are these different? If so, what information are we providing to the operational planner and strategist to help in making their

decisions as to which technique will be most effective? Let me call your attention to the increasing complexity of our systems. The F-4, for example, has some 2,072 reparable, exchangeable parts; the F-15 has over twice as many--4,335. In airlift, the C-130, as a baseline, had 1,945 reparable, exchangeable units associated with it. The C-141 has in excess of 3,200 and the C-5 almost 8,800 individual reparable units. Placing this in a slightly different context and looking at the cost per flying hour, not including fuel cost, we see that the F-4 costs $200 per hour, while the F-15 is $475. The C-130 costs $85 an hour for parts and repair while the C-5 is approximately $1300 per hour.

Clearly stated, I would say the question before this group is this: How can we manage a smaller number of spare parts, do it more quickly and accurately, and with fewer people and yet put some element of judgment and management experience and expertise into the process of defining requirements, and establishing relative priorities between varied sub-elements, parts, and pieces? We went to the technology repair center concept for good reason. Now it would appear that we must address the issue of how we provide the item manager with the necessary total visibility into his stock-coded items as well as those that impinge and influence his items, and how do we do this in a less costly fashion but in a more timely manner. As we dust off the harvest reaper kits and see more indications that forces employed in certain areas of the world may in fact be on very austere conditions, we must of necessity ask ourselves if we are prepared to respond in the support of our engaged units, in the quantities needed, and in the time-frame necessary.

Our foreign military sales activities, of course, impact all of that. The international diplomatic needs sometimes (and it seems like more frequently now than a few years ago) impact our current Air Force capability. To provide near-term logistics support, we take items destined for USAF usage and transition these to the FMS case with the replacement in kind occurring some years down the time scale. And more frequently than we'd like to admit, it appears that we are making very little progress in increasing durability, reliability, and maintainability in our basic design efforts. Cost, schedule, and pushing the state of the art in performance seemingly continue to take the forefront at the expense of these other logistics life cycle cost factors.

The dwindling supplies of strategic metals is cause for serious concern, and the fact that many of these materials and OERs come from portions of the globe which are either under the Soviet control, influenced heavily by the Communist factions, or could easily be cut off by Soviet forces, might present very serious limitations in future years. Obviously, the maintenance of the necessary

quality assurance overlays all of this.

Compounding the problem of requirements versus support is the fact that there appears to be an ever-widening gap developing between peacetime flying hour programs and the wartime surge requirements for our major systems. In one case, for example, in strategic airlift, the difference between these two requirements on daily utilization rate is an order of magnitude or better. And with most of our fighters we see the plan for utilization rates of at least five to eight hours per day, or three to four sorties per day, vice peacetime operations of less than one.

Perhaps not as clearly recognized as other limitations is the fact that there appears to be a constantly changing nature of the workload required of the logistics support system in accommodating to the operational flying unit's needs. In the past, this repair has largely been hardware intensive and, while there will always be a certain level of structural repair, skin damage and battle damage repairs needed, it currently appears that the major change is toward more complex electronic systems. We see microprocessor equipped systems, embedded computers, and software driven subsystems, fire control and flight control activities. Each of these require very different tools, machines, and skills to work with.

We're driven away from the sheet metal shops and the machine shops to computerized test equipment and highly sophisticated electronic sensing and programming techniques. Many of you know the avionics and intermediate shops for weapon systems like the F-15 are posing serious problems at this time. Even a rather cursory review of those problems and the operating techniques of the system indicates there are certain very definite shortfalls in durability and operability of those test ventures. Solutions are not easy. They are certainly less than obvious and quite possibly not achievable in the near term. In all probability, we will have to direct a sustained and rather sizeable effort to even quantify the problems and the solutions at this point without costly duplicity. We may, in fact, miss the mark completely and fail to develop solutions for significant problems. In fact we have yet to devise adequate test procedures to stress the entire logistics support posture and procedures. Obviously, this can't be done on a broad base and we have great difficulty doing it vertically through a large portion of the force. And in the past, we have not been able to continue the test for an adequate period of time to gain the needed insights. I know, however, that several agencies are working to rectify this.

Turning from pure logistics problems, let me say that past solutions involving ingenuity, mass production, industrial

responsiveness and might, and unified concerted dedicated action in response by the American public, might not even be called into play as they were in World War II. Instead, carefully staged, creeping takeovers, masked by the involved countries' internal civil problems, or takeovers under the thinly disguised cloak of providing assistance in stabilizing a turbulent situation at the call of one of the involved parties, or takeovers from the bold application of military force over a short period of time in a very decisive way, followed by a period of consolidation, regrouping, etc., with a political and diplomatic rhetoric to explain the peculiarities of the particular situation--all of these can, if carefully used, achieve a continual success without ever raising the level of concern of the American public to a point where there is a national outcry and a willingness to risk either massive involvement or retaliation for what the other side will explain as very limited, regional goals and needs.

In reviewing these thoughts, I find I've presented very few if any solutions. I think I've outlined problems that most of you to some extent are quite familiar with. But perhaps by putting them in an overall assessment such as this we may better structure our joint efforts in reaching a solution.

Let me call your attention to the joint statement of the Secretary of the Air Force, Verne Orr, and our Chief of Staff, General Lew Allen, in their statements before the committees and subcommittees of the United States Senate on the posture of the United States Air Force. General Allen stated that the principal security challenge facing the United States is the threat posed by the continuing growth of Soviet military might. It is the imperative need to counterbalance Soviet military capabilities that sets our military requirements and fundamentally sizes and shapes our forces. He went on to point out that the United States has a unique responsibility for maintaining an effective strategic nuclear deterrent and an acceptable balance of central strategic and regional nuclear capabilities with the Soviet Union. To fulfill this key responsibility in the face of the continuing buildup of Soviet nuclear capabilities, we must proceed apace with the strengthening of our strategic forces set in motion last fall. He also pointed out that it fell to the United States to provide the leadership in attempting to contain Soviet expansionism.

On 15 January 1981, the Washington Post carried an interview with U.S. Ambassador to the Soviet Union, Mr. Thomas Watson, Jr., in which the Ambassador stated that the Soviet Union poses a grave danger to world peace and stability that must be met by the United States, whatever the cost. Mr. Watson went on to say that he did not believe the west had any conception of how dismal the future

looks for east-west relations. He stated that he believed there was "no hope" of any change in the Kremlin's global ambitions even from the eventual successors to President Leonid Brezhnev. Lots of people say that when the post war leadership comes along, people without parents who grew up in the revolution without memories of World War II, they will change. Mr. Watson expressed the opinion that he did not believe things would change and went on to state that this is one of the most stable governments on the face of the earth. There is no hope of collapse--no hope of change. I believe we have far too great a tendency to attempt to analyze any potential Soviet behavior in light of our own attitudes, feelings, and reactions, rather than from the Soviet outlook.

Recently W. Averell Harriman, who has served five presidents as an envoy and diplomatic trouble shooter said: "I remember saying in San Francisco at the founding conference of the United Nations in 1945, that our objectives and the Soviet objectives were irreconcilable, that we would have to find a way to adjust our difficulties to deal with international situations and compose our differences in regard to war on this small planet." I think that there is this absolute irreconcilable difference: The Soviets have never written this in quite this way, I don't think, but the Russian objective is to have as much of the world Communist as possible. This is their ideological goal. They think their security will be best enhanced by Communist dictatorships, as we call them; we, on the other hand, believe our security and best interests are best served by democratic governments, namely some form of government that is responsible to the will of the people--and that's an irreconcilable difference. Each of us should be very much aware of this reality.

Those of you who believe the assessment that the Soviet Union is a very defensive-oriented nation should be very much interested in an article by Professor Richard Pipes of the History Department of Harvard University. Pipes wrote in the fall of 1980 Daedalus Magazine that ignorance of Russia places western statesmen at a great disadvantage vis-a-vis their Soviet counterparts who have always had a keen interest in western societies. To a historian of Russia, the assertion that throughout its history this country has undergone an extraordinary number of foreign invasions and, as a consequence, developed a collective paranoia simply does not hold water. It is true, of course, that during their thousand year old history, the Russians have suffered three particularly devastating invasions--by the Mongol-Tartars in the thirteenth century, by the French and Prussians in 1812, and by the Nazis in 1941.

But are the people who subscribe to this view aware of the number of times the Russians have invaded and inflicted comparable

traumas on their neighbors? After all, a country does not become the largest state in the world as Russia has been since the seventeenth century merely by absorbing or repelling foreign invasions. How many, apart from specialists, know of Russian aggressions, such as the sixteenth century offensive in the east that resulted in the subjugation of the Moslem principalities of Kazan and Astrakhan, the conquest of the seventeenth century of Siberia, the continuous offensive against the Ottoman Empire, the partitioning of Poland in the eighteenth century, or the conquest of Turkestan and the seizures of Chinese territories in the nineteenth century. It is by means of this relentless movement outward that Russia has expanded to occupy one-sixth of the earth's land surface. To recall this record is not to attribute to the Russians uniquely aggressive proclivities--it is merely to correct widespread misperception of them as a uniquely defensive-minded people. To carry out its conquest, Russia devoted the lion's share of its national wealth to military purposes. It is interesting to note that, even today, in a time when the United States--perhaps the wealthiest nation on the globe--feels oppressed because it must invest about five percent of its gross national product for defense, that the Soviet Union, a nation beset by crop failures, poor consumer economy, and difficult times, sees fit to devote 13 to 15 percent of their gross national product to defense--or said another way--to arms which could be easily used for offensive purposes.

Now what does this suggest? We know, for example, that over the past decade the Soviet Union has outspent the U.S. by some 300-350 billion dollars in defense arms. As pointed out by General Kelly Burke, DCS/R&D recently, the Soviets have spent on the order of seventy billion on their land-based ICBMs alone during this past decade, building a large number of very highly accurate weapon systems. There's simply no argument for having such accuracy in an ICBM force other than to threaten our own silos. You do not need to buy precise guidance systems if you are only going to attack cities or Air Force or Army bases or submarine pens. But there are those who voice their opinions very loudly that it's impossible to assess intentions only from counting arms and military might, and certainly they have a point. In the 18 January 1982 issue of Time magazine, in the National Section, Editor Hugh Sidey wrote an article titled: "Needed: A Grand Strategy." He said Admirals and Generals do not win wars. Presidents do. Consider Washington, Lincoln, Wilson, and Franklin Roosevelt. According to Sidey, they each had a vision, a grand strategy which realistically used the power we had. Without this vision, as Korea and Vietnam exemplify, there can be no victory. In Government Executive magazine of October 1981, Secretary of Defense Weinberger clearly says that U.S. strategic policy was premised on our most basic goal--to maintain peace with freedom. He pointed out that peace alone is not enough.

In a tortured way, Poland is at peace. He went on to say that we must have freedom with peace. He summed it up by saying that, while there are certainly threats to American security interests independent of the Soviet Union, growing, far-reaching Soviet military power clearly posed the most serious and imminent danger to the United States. He pointed out the massive Soviet military buildup that is continuing both in nuclear and conventional forces unabated, and assessed that these Soviet weapons were not being built for defensive purposes, that they were being built to give the Soviets a greater ability to carry out their political aims, and that it would be dangerously naive to expect the Soviet Union, if it once achieves clear military superiority, not to try to exploit their military capability even more fully than they are now doing.

We must assume some rationale behind the Soviet Union's enormous allocation of resources to the military at the expense of their other basic needs, he pointed out. I believe it's important to understand that Secretary Weinberger's feeling is that a reordering of priorities is always more meaningful, particularly in an era of budget stringency, if it is explicit about the things that are less important. To say everything is more important is not saying very much. He then went on to point out that what isn't important is the funding of weapon systems merely to make our forces nearer the Soviet Union in terms of a superficial tally of missiles, bombers, fighters, and the like. Obtaining asymmetry between U.S. and Soviet forces in terms of such superficial counts is not a requirement important enough to qualify for our scarce defense dollars. The Secretary made three key points:

First, our defense policy must be viewed in a global context. Our interests worldwide and the threat we face is also worldwide. We cannot afford to neglect one area to bolster another.

Second we have become an island nation. Many of the resources we need for energy and many essential strat gic minerals are found thousands of miles from our shores. If we are to safeguard our access and the access of the free world to these resources, we must increase our military and naval strength.

Third, it is the cornerstone of our policy also to develop a rational division of some of these burdens so that our allies with their own enormous strengths can join together with us in contributing more to the common defense in securing peace with freedom.

Those points, taken with added instruction in Secretary Weinberger's "Defense Guidance" to the military to modernize and/or acquire personnel/hardware resources for the following basic aims,

I believe, establish clearly the policy and strategy of this administration. As you will recall, the "Defense Guidance" instructs the military departments in structuring their resources and equipment to address the following issues:

One--prevent the coercion of the United States, its allies and friends;

Two-- be capable of protecting the U.S. interest and U.S. citizens abroad;

Three--maintain access to critical resources around the globe, including petroleum;

Four--oppose the geographic expansion of Soviet control and military presence worldwide, particularly where such presence threatens our geo-position; and

Five--encourage long-term political and military changes within the Soviet empire that will facilitate building a more peaceful and secure world order.

I am most encouraged at what these statements of policy say, for they correct deficiencies in our foreign diplomatic conduct of past years. For perhaps fifteen years or more, we have been misled by some illusion that we merely had to modify in formal agreements some existing U.S.-Soviet understanding and the Soviet strategic nuclear buildup on the strength of a treaty document alone would tail off. I've long felt that was one of the weakest and most ill-founded cornerstones of U.S. defense policy.

We haven't talked about specific models of techniques.

We haven't talked of the overall strategy to be pursued--or to what extend modeling will or will not influence the development of that strategy.

We haven't talked about the ever growing imbalance of forces--or the ever increasing flow of technology to the east and the slow down in scientific development in our own universities.

Each of you has a key role to play--be sensitive to the broader issues and decisions being made--aid them and this nation's security where and when you can.

Thank you, Leo, for that kind introduction. I am very pleased to have been invited to be with you here at LOGCAS 82 because I firmly believe that great strides can and are being made in logistics capability and readiness. My adaptation of the adage that "the Army travels on its stomach" is that "the Air Force truly flys on its logistics support." Another way to say that same thing is "the logistics tail really does wag the sortie generation dog.'

In a few short months my tour as Air Force Chief Scientist will come to an end. I have often told my colleagues that this is the greatest job an inquisitive college professor could have. I have had the license to literally cover the technology waterfront, so to speak, and I have done just that. This is an exciting technological era and I am fortunate to have had the opportunity to join the Air Force in its endeavor to maintain our technical edge.

Tonight I want to share with you some of my thoughts about interfaces. Both man-machine and machine-machine. I guess I could, with tongue in cheek, entitle my talk "the man-machine/machine-machine interface" or "how to ruin an otherwise great system."

Let me begin with a few examples.

First, I am sure that all of you can point to horror stories where a new system under development was discovered not to be compatible with the system it was designed to support or with one or more associated subsystems. For some reason, the collateral interfaces always seem to be considered as an afterthought. A vivid example in the machine-to-machine interface area occurred when the Air Force was readying the A-10 for OT&E flight testing at Nellis. We had two contractors participating in a modification to install an Inertial Navigation System on the A-10. One contractor was manufacturing the INS control panel and the other the Inertial Measurement Unit (IMU). Both contractors were building to the same interface specifications. The initial units went through interface certification tests at the respective builder's plants using only the builder's hardware. Each contractor came through this test with a list of deviations but they thought their deviations were inconsequential. The judgement day arrived at Nellis when the two pieces of hardware were finally mated in the A-10 test aircraft. Lo and behold they couldn't talk to one another. Of course, each contractor pointed his finger at the other, but the fact of life was that even with what appeared to be reasonable care on the part of all parties, the machines could not interact. We were able to resolve the problem only after flying the interface certification test equipment to Nellis to determine which "inconsequential deviation" from the interface spec was at fault.

SPEECH

FOR THE

LOGISTICS CAPABILITY ASSESSMENT SYMPOSIUM (LOGCAS) 82

DELIVERED AT THE

UNITED STATES AIR FORCE ACADEMY

18 MARCH 1982

DR. EDWIN B. STEAR

CHIEF SCIENTIST OF THE UNITED STATES AIR FORCE

A couple of years ago I was a very interested observer at a command and control exercise. The objective of this exercise was to give command post personnel an opportunity to train under simulated battle conditions. I was there to observe the general operations and was interested in a new computer based system for assisting combat planning which was being employed by the combat plans unit of a TACS (Tactical Air Control System). The purpose of this new system was to improve the flexibility and effectiveness of combat planning by improving the speed and accuracy of the unit's response to the next day's apportionment and allocation order of the available tactical air forces. When I asked one of the combat planners, whose duties included keeping the electronic Order-of-Battle (EOB) up-to-date, how he liked the system, he said he didn't like it and didn't use it. He stated that he could maintain the electronic Order-of-Battle faster by the old manual method using a loose-leaf notebook. He explained that in order to get the EOB to come up on the video screen so that it could be updated, he had to enter a long string of precisely ordered characters from a keyboard, a process which was both time consuming and error prone. This procedure was clearly much more time consuming than simply reaching for the notebook on his desk and opening it to the right tab. I later found out that there were similar access and manipulation difficulties with other functions incorporated in the computer-based system. The question is: What happened during the design of this system which allowed such a difficult man-machine interface to proceed all the way to hardware delivery?

At the present time, I am working with a new, very capable microprocessor system. It is used for the development of software for various configurations of systems based on one of the newest and fastest 16 bit microcomputers. As usual, it comes complete with floppy disks containing a wide variety of software utilities and at least a 6 inch high stack of manuals with many revisions and addenda. The problem is that the system is very hard to learn to use. The manuals appear to be complete in that they apparently cover all aspects of the system's elements and how they function. Unfortunately, it is extremely difficult to find out exactly where these items are discussed. There is no concise initial user's guide with proper references to the voluminous manuals that are necessary to provide the many details of system design and operation. There is not even a compact list of the system commands and their syntax. Moreover, there are many discrepancies between the manuals and what actually happens during system operation. Error messages are not as they appear in the manuals because of changed error numbering and/or naming. However, if one takes the time to do the necessary deciphering of the error message, it is possible to properly locate and interpret them. Like many of its counterparts, the system is almost too hard to learn to use if you have to rely solely on the documentation provided; however, it does

yield grudgingly and slowly to a persistent attack involving much playing with the system, successive and "excessive" re-reading of the manuals, and occasional long distance calls to the manufacturer's experts. It is easy to see how one could take real pride in having mastered its use and how a measure of job security might derive therefrom.

These anecdotal stories each involve rather different situations and settings, yet they have one very important element in common. To wit, they each represent an example of a poor to unacceptable interface between systems or between the users of the system and the systems themselves. It is on the nature and design of these interfaces that I wish to focus.

Let me first discuss the Air Force's progress in dealing with the machine-to-machine interface because in some sense it is the easier of the interfaces to improve.

In the late 1960's and the early 70's, as digital technology began to appear in Air Force systems, it occurred to some people that systems integration was becoming a major factor in fielding effective systems. We were proliferating digital computers and we were having difficulty managing software. As a result, computer software was becoming a very significant factor in both cost and schedule for new systems.

To deal with these problems we started the Digital Avionics Information System Program, or DAIS for short. DAIS targeted four areas for emphasis: First, digital computers; second, software; third, multiplex systems; and fourth, the controls and displays associated with avionics systems.

The DAIS display work concentrated on questions of how to use CRT's to display the information a pilot needs and how to manage the displays so that a pilot can handle all of the available information. The result was a cockpit similar to that in the F-18.

The design of the multiplex system was driven by the desire to simplify the integration of the subsystems in an avionics system. At that time (during the Viet Nam war) there was a mix of analog and digital systems being hurriedly installed in aircraft. Every system had a unique interface with every other system, which made system integration difficult. In some cases the need for rapid response resulted in poorly integrated systems with reduced effectiveness.

With the evolution of the MIL-STD-1553 serial digital multiplex bus, it became possible to define a standard interface between digital systems, and with the help of a remote terminal, it

was possible to interface an analog system to digital systems in a relatively simple way.

The work that DAIS did with the MIL-STD-1553 bus establishes the limits of what the bus can do and formed the basis for issuing the current version of the Standard (MIL-STD-1553B). MIL-STD-1553B is not only a US DoD standard, but has been adopted without change by the UK and also by NATO.

In the Air Force we have a policy that requires a MIL-STD-1553 interface on all new avionic subsystems so that they can be easily integrated into an avionics system.

The MIL-STD-1553 multiplex bus forms the central nervous system of the avionic architecture that we are installing in almost all of our aircraft. The F-16 had it from the beginning, and it will be put into the F-15 for AMRAAM and JTIDS. The B-52 got its multiplex bus when the offensive avionics system and the digital Inertial BOMB/NAV System were added to the aircraft. The F-111 gets a multiplex bus when the new digital computer replaces the existing computer. The A-10 got a multiplex bus when the inertial navigation system was installed in the aircraft. Even our cargo aircraft will get the bus as part of the fuel savings advisory system for the C-5, C-141 and KC-135.

So you can see that as we proceed with the avionics updates of our existing aircraft, we will put into them the pieces that are needed to integrate future avionic subsystems.

In the computer area we don't have a hardware standard, but we do have a standard that defines the instruction set of a computer, though not its hardware implementation. This means that it is possible for program managers to get their contractors to build MIL-STD-1750A computers, or to buy them, and to use existing off-the-shelf versions until their hardware is available. It also allows each program to tailor the particulars of the implementation to meet unique program needs. A program that only needs a small amount of memory is not forced to use a computer that someone else has developed and contains more memory than they need, or one that is too big, or requires more power than they can afford; yet the program that must have a very fast machine or a very large memory can develop a machine which is software compatible but tailored to meet their needs.

As a measure of the success that we have had in implementing MIL-STD-1750A, we currently have over fifteen vendors willing to sell MIL-STD-1750A computers in versions that range from large 1-ATR conventional avionic computers that run at four to five hundred thousand operations per second, to smaller half-ATR computers

that run at the same speed, to a minicomputer version with disk and printer interfaces for automatic test equipment but with a very large memory, to microprocessor versions which will run at eight hundred thousand operations per second over the full military temperature range. Programs using MIL-STD-1750A computers include F-16, F-111, LANTIRN, F-5G, B-1, and the modular automatic test equipment program, with others soon to follow.

At least two VHSIC (Very High Speed Integrated Circuit Program) contractors are building the chips necessary to make extremely fast processors. For example, Texas Instruments is currently planning to implement a MIL-STD-1750A computer with 64K words of memory on a four-by-five-inch card. It is projected to execute over four million instructions per second and to consume less than ten watts of power.

Well, so much for hardware. We are on a good, accelerating path to a more logistically supportable future!

In software, the DAIS program adopted the Jovial J73/I language. This language has since been merged with the Jovial J3B language to form Jovial J73, the Air Force standard high-order language. A consolidated support software environment is being developed for J73 and will be available for any contractor that desires a copy of it. All of the programs that are planning on using MIL-STD-1750A computers are also using the J73 high order language.

Some programs are even considering the evolution of ADA in their use of J73. Aerospace Corporation has developed a set of rules for things to avoid when coding in J73 to simplify the conversion to ADA if that becomes desirable.

So, with that as a background, let me tell you where the Air Force is headed in our goal of improving machine interfaces and how we will get there.

In aircraft systems, only avionics and weapons change. Almost without exception, an airframe does not change over its life. We may make some structural modifications to fix deficiencies such as the C-5 and the F-111 wing modifications, but we don't change the airframe structure or its aerodynamics in any very noticeable way. We also do not generally put a new engine in an old airplane, though that may occur in the future with the KC-135 re-engining program.

As a matter of course the avionics and weapons on a given aircraft are in almost continuous change. It is primarily these changes which maintain the basic capability of the system, and

without them our first line systems would become obsolete in a very short period of time.

But high costs for modifying aircraft result in delayed introduction of advanced avionics and weapons capability.

You can view this as corollary one of the statement I just made. Because the cost of opening up an aircraft for modification is so large, in many cases we wait until we have accumulated a number of modifications before we accomplish any of them so that we can average the cost over the number of modifications to be incorporated. As the cost of opening the aircraft continues to grow we delay even further the installation of new capability in order to keep the average cost of modification down. So as an airframe ages its capability tends to lag further and further behind current technology. However, we are going to continue to operate with severe resource limitations.

With MX and B-1 taking such a substantial fraction of our total research and development budget there will be a resulting smaller absolute dollar amount available for other programs.

In order to cope with these facts, we are undertaking four parallel initiatives which deal directly with the subject of interfaces.

First, we are going to develop the next generation architecture for aircraft avionics under the Pave Pillar Program. As I pointed out before, a baseline avionic architecture is available today in the F-16, for example, but it needs to be extended to match the operational and logistics needs of the future to the evolution of technology.

Second, we are going to undertake subsystems developments which stress evolution within an architectural framework. We think that this has major potential to ease the cost problem for retrofits and modifications.

Third, we plan to coordinate developments across weapon systems and technologies to avoid duplication and incompatibilities.

Fourth, we intend to do some development in advance of stated requirements where those developments are sufficiently generic to be applicable across a wide spectrum of systems and can be applied within the context of the baseline architecture.

Under the Pave Pillar Program we will be developing the next generation avionics architecture, and one of the things we must guarantee is that new equipment must be able to be applied to

aircraft which have only the current baseline architecture installed. That it, a new box which is developed for a new fighter should also be applicable to the F-16. Major investments in compatible avionic systems just don't make sense. We have a tremendous investment in existing aircraft (F-15, F-16, A-10, F-111's, and soon B-1's). We know those systems will be evolving over time and we must take advantage of developments for new aircraft (or for old aircraft) across the fleet.

We are working with our NATO allies in two different NATO working groups to keep their involvement high in our avionic architecture developments. NATO adoption in STANAG form of MIL-STD-1553B and MIL-STD-1760 (the aircraft to stores electrical interface) are significant steps toward standardizing on an avionics architecture across NATO.

As an example of our evolutionary approach to subsystem development, the radar for the B-1 will be an F-16 derivative. The internal partitioning of a radar into a receiver/exciter section, an antenna, a power amplifier, a programmable signal processor and a data processor, all tied together with an internal bus, allows us some future potential commonality between radars in various aircraft. As part of our radar long-range planning we are looking for ways to standardize on the internal interfaces within the radar.

Both the F-15 and the F-16/B-1 radars will have MIL-STD-1750A computers and J73 software. We should be able to increase commonality between these radars through reuse of software.

By properly defining the interface between the internal boxes of the various sections of the radar, we hope that as technology advances (say in the area of active elements for antennas) to be able to retrofit future radars with advanced technology without completely replacing the radar.

Well, so much for the future of the machine-to-machine interface. We are now moving in the right direction and proceeding with increasing velocity. But, what about the man-machine interface?

Well, let me now put man in the loop. All of our activities involve man-machine interfaces all of the time. Most of them and our adaption to them in our daily life have evolved to the point that they are effectively transparent. Think about car handles, shower faucets and automobile controls. Good human interfaces should have this reality. They should be relatively transparent to the users of systems so that the users can concentrate on the activities or functions they are trying to control or influence.

The real issues in the man-machine interface begin with some fundamental questions, such as whether or not an effective human

interface can even be created to enable man to interact with a given system in a certain manner in view of his inherent physiological limits. Such questions extend to the degree of automation required to offset physiological limits at the human interface, and of course include the cost and complexity of the interface.

Let me now explore these issues further in the context of a specific problem area of current interest to the U.S. Air Force. It will become clear in the process that the problem area selected has some reasonable relationship to the anecdotes that I presented earlier.

The Air Force has a considerable capital investment in F-16 and A-10 aircraft which are our primary ground attack vehicles through the year 2000. We need a weapons delivery system which will give these aircraft the capability to destroy high value, mobile ground targets at night or in adverse weather conditions. And we would like to get as many kills as possible on a single pass to improve aircraft survivability in the high threat environment of central Europe.

Let me set the stage by putting you in the cockpit of an F-16 fighter. You are carrying 6 Maverick missiles and your mission is to destroy a column of aggressor tanks which have just crossed the west German border. The weather is clear. You are leading a flight of four, hugging the trees at about 200 feet and trying to hold 500 knots indicated airspeed. You have a preplanned initial point about 20NM from your present position straight in front of your nose. Intelligence sources say that the tanks are 030°, 10NM from the initial point. In somewhat less than four minutes from right now you will hopefully have launched one Maverick missile at a tank and started maneuvering for a reattack. In the interim, you will have armed the missiles, proceeded to an offset point, popped-up, visually found the targets, picked out tanks from trucks and armoured personnel carriers, selected one tank to strike, aimed the missile electronically, and finally, squeezed the firing trigger. I am sweating right now just thinking about all the bullets and missiles coming up from the ground, not to speak of the tremendous workload on the F-16 pilot. Now add night or bad weather to the scenario and what was a difficult mission becomes impossible.

The LANTIRN Program (Low Altitude Navigation Targeting Infared for Night POD Systems) evolved from the need to make our ground attack fighter force effective in the scenario I just described when you add night or adverse weather conditions.

One of the many initial problems facing the LANTIRN developers was the decision of what tasks should be automated to reduce pilot workload to an acceptable level. On the other side of that issue

was the maturity of the technology so vital to the automation process. Keep in mind the goals-multiple kills per pass at night or in adverse weather.

There were two general schools of thought when it came to defining the man-machine interfaces for LANTIRN. On one hand were those who favored automating the flying tasks in order to free the pilot to perform the target detection, recognition and destruction duties.

The issues in this approach quickly focus on the ability of the pilot to perform his targeting and weaponeering tasks in the high pulse rate battlefield environment I just described -- high speed, low altitude, multiple kills per pass. Picture the pilot peering at a FLIR display trying to concentrate on searching the image for tank targets, manipulating cursors to select a target from the cluttered background, selecting missiles and then depressing the firing button-while hurdling himself just above the ground at the rate of nearly 3 football fields per second - while relying solely on the terrain avoidance radar and autopilot to keep from ruining his day - or night!

Given man's limited target detection capabilities - slow, degrade under stress, etc., it seems clear that this is <u>not</u> the proper man-machine interface to pursue if we are to achieve multiple kills per pass.

The other school of thought advocated automating the targeting and weaponeering functions and letting the pilot fly the aircraft. I counted myself among this group along with, I am sure, most of the fighter pilots in the Air Force. This is the group that prevailed. It prevailed because it could capitalize on our truly great modern electronics capability which has the only real potential for achieving multiple kills per pass.

Basically LANTIRN as envisioned today would work like this. A low altitude ingress would be made into the target area using a FLIR image projected onto a wide field of view head up display. The pilot would manually follow the terrain as viewed through the FLIR. In the target area, a high resolution FLIR would be used as the target sensor. An automatic target recognizer system would process the FLIR data, select the highest priority targets, match a Maverick missile to a target, and automatically launch the missiles. Remember, the goal is to launch as many missiles as possible on a single pass.

It is within this system concept that some of our best design engineers are trying to take advantage of the inherent processing speed of our latest computers. Nevertheless, we really are pushing technology. You can imagine the tremendous amount of data that must be sorted by the computer and the great degree of difficulty facing the machine in its task of selecting real targets from the background

clutter. Therefore, the prudent man must realize that target recognizer technology is still evolving and may not be quite ready to step up fully to such demanding tasks. Thus we should be prepared to approach the night, adverse weather problem with a LANTRIN which grows as technology matures. Our program managers and equipment designers must ensure that the machine-to-machine interfaces are designed in such a manner that an evolutionary P^3I approach can be accommodated without experiencing similar problems to the examples I cited earlier.

Clearly the hardware and software must conform to our established avionics architecture. Future machine-to-machine integration must be guaranteed. The only aircraft modification acceptable beyond initial installation is a remove and replace program that can be accomplished in the field. We must insure that the pilot can effectively and efficiently interface with the evolving system and pilot workload must be recognized as the critical design driver it truly is. The man-machine interface has to be simple and it has to work. In LANTIRN, we have a chance <u>not</u> to ruin an otherwise great system. We better be equal to the task because the combat fighter pilot is betting his life on it.

SPEECH

CLOSING REMARKS

FOR THE

LOGISTICS CAPABILITY ASSESSMENT SYMPOSIUM (LOGCAS) 82

DELIVERED AT THE

UNITED STATES AIR FORCE ACADEMY

19 MARCH 1982

MAJOR GENERAL LEO MARQUEZ

COMMANDER OGDEN AIR LOGISTICS CENTER

Good morning ladies and gentlemen. It's a real pleasure for me to be here and doubly flattering since this is the second time I've been asked to deliver closing remarks to this Symposium. Although I haven't had the chance to listen to the briefings being given this week, I am familiar with most of the work being done in the capability assessment area. I've also had the good fortune to meet and talk with a fair number of you about your work. In my last few jobs, in the AFLC, and HQ USAF log plans business, as well as in my current command job, I've seen a good number of assessments and been asked to act on them. So I think I've got a good sense of where we are in this business and how much we've got to do to make assessment modeling really influential in decision making.

Let me give you a thumbnail sketch of the ground I want to cover. First, I want to give you credit for the tremendous progress that's been made in capability assessment modeling. After giving you my perspective in this area, I'll talk about some of the shortfalls we have in this business. But the thrust of my remarks, in keeping with the theme of the Symposium, will be on giving you a roadmap of what needs to be done to make capability assessments more useful in management decision making. This roadmap indicates that we have to develop assessment models that deal with vertical and horizontal organizational decision issues. We need tools that give us the capability to measure the impacts of various base and depot resourcing and policy decisions on combat effectiveness. We can no longer afford to treat the base and depot systems independently. We must know how they interact to produce combat outputs. Thus, you need to build models to deal with what I call these base-depot or vertical integration issues. I'll talk to some specific needs in a minute.

Next, the assessment tools of the future must be able to measure the impacts of how logistics support alternatives impact multi-theater operations. We can no longer afford to look at single theater operations. We need to know how draw-downs of resources in one theater affect other theaters. If we have to "rob from Peter to pay Paul" we need to know what the residual forces can sustain in combat. Thus, you need to build tools which can assess what I called multi-theater or "horizontal" decision issues.

The burden is not all yours, however. We in the management hierarchy must build organizations and communications channels which can deal with this assessment information and put it to work. This is not as easy as it sounds because what I'm asking you to do is build some tools which will provide information. That will question some of our requirements modeling outputs. We have to make sure we structure this check and balance system in ways which will lead to enhancing our resourcing processes and not detract from them.

Finally, I want to leave you with the challenges of helping me to fully develop this roadmap so we can present a well developed plan of how this work fits into our management process. We need your thoughts on how to harness the capability you're creating to make it truly productive.

Let's back up now and begin to put some flesh on this outline so you'll get a better idea of where I'm trying to lead you in your efforts. Let's begin by talking about where we are in the state of the art of capability assessment modeling.

Let me start by saying that the progress made in this area in the last three years has been remarkable. You've made real progress in getting combat measures, like sortie generation capability, into the objective functions of your models. There's been movement in inputting important decision parameters and allowing for expanded sensitivity analyses. There's been tremendous movement in bringing in more resources under the modeling umbrella. There has also been movement in reaching a concensus on what modeling techniques are best, to help evaluate certain resources. In short, your work is leading to better information being provided to us decision makers.

On the decision making side, we as a group have a much better understanding of the usefulness of models in our decision processes. Through education, our senior managers have better ideas of what models can do for them, as well as what models cannot do for them. A better dialog has been established between we decision makers and you modelers on what we believe is important to be modeled. And you've reacted very well. We've also been using these modeling products to influence our decisions much more than we used to.

To wrap this portion up, let me make it a little more personal. Those of you who know me, know that about three years ago I was advocating what I called the "stable of models concept." Basically what I was calling for was the parallel development of capability models attacking the same set of problems. It was my worry at that time that we just didn't have sufficient credibility and that any single analysis was vulnerable to attack. This could discredit our whole effort. So I tried to encourage multiple developments. But now I believe we've reached credibility in several areas so we can concentrate on developing specific models for specific situations and standardize some assessment techniques. In other words, I think we have a proliferation of models attacking the same problem, all using different techniques and all using different assumptions. We need to settle on the techniques to be used for particular resources.

USAF LOGISTICS CAPABILITY ASSESSMENT SYMPOSIUM 82

Major John W. Schade 225-4895
HQ USAF/LEYSP
Washington, DC 20330

Captain K.C. Schwarz 244-0346
AFTEC/LG4
Kirtland AFB, NM 87117

Lt Colonel Bill Smiley 227-4560
HQ USAF/LEXY
Washington, DC 20330

Colonel William T. Stallings 638-2208
HQ MAC/XPS
Scott AFB, IL 62225

Mr. Frank Strauch 430-5540
NFMSO (Code 932)
Mechanicsburg, PA 17055

Colonel Glen Sutton 858-2591
HQ AFSC/LGM
Andrews AFB, MD 20334

Colonel Donald C. Tetmeyer 785-6797
AFHRL/LR
Wright-Patterson AFB, OH 45433

Major Randy Thomas (213) 393-0411 X631
AFELM - Rand
The Rand Corporation
1700 Main St.
Santa Monica, CA 90406

Major Clyde Thompson 785-2837
ASD/ENESA
Wright-Patterson AFB, OH 45433

Lt Colonel Robert Tripp 458-5430
Directorate of Material Management
Ogden Air Logistics Center (MMM-1)
Hill AFB, UT 84056

Second Lieutenant Randy Verble 921-4524
AFLMC/LGY
Gunter AFS, AL 36114

USAF CAPABILITY ASSESSMENT
LOGISTICS
SYMPOSIUM
82

Major Dale T. Pearson HQ USAF/SAGP Washington, DC 20330	227-0862
Mr. Bob Petruschell The Rand Corporation 1700 Main St. Santa Monica, CA 90406	(213) 393-0411 X7273
Lt Colonel Edward Ponder USAFA/LGS USAF Academy, CO 80840	259-2010
Major William Power HQ AFLC/LOA Wright-Patterson AFB, OH 45433	787-7935
Mr. Victor J. Presutti HQ AFLC/XRS Wright-Patterson AFB, OH 45433	787-4406
Captain Joseph P. Racher, Jr. AFLMC/LGM Gunter AFS, AL 36114	921-4583
Mr. Tom Rather HQ AFLC/XRPEA Wright-Patterson AFB, OH 45433	787-3981
Mr. Horatio Robinson WR-ALC/DSM Robins AFB, GA 31098	468-3167
Mr. Bernard Rosenman Army Inventory Research Office Room 800, US Customs House 2nd & Chestnut St. Philadelphia, PA 19106	(215) 597-8377
Major Fred Saliba AFCOLR Wright-Patterson AFB, OH 45433	785-3302
Lt Colonel Jerry Saxton HQ AFLC/XRS Wright-Patterson AFB, OH 45433	787-3201
Senior Master Sergeant George E. Scarborough HQ MAC/XPMF Scott AFB, IL 62225	638-2921

USAF LOGISTICS CAPABILITY ASSESSMENT SYMPOSIUM 82

Major Harry Mathis *HQ ATC/LGX* *Randolph AFB, TX 78150*	487-4341
Lt Colonel James F. McDermott *HQ USAF/LEXX* *Washington, DC 20330*	227-2831
Mr. Gordon Milne *OO-ALC/MM* *Hill AFB, UT 84056*	458-5430
Lt Colonel Ray *Mitchell* *AFLMC/LGY* *Gunter AFS, AL 36114*	921-4524
Mr. Gene Mortenson *OO-ALC/MMS* *Hill AFB, UT 84056*	458-5430
Mr. Lloyd K. Mosemann II *SAFALG* *Washington, DC 20330*	277-3624
Mr. Robert Neibling *AFDSDC/LG* *Gunter AFS, AL 36114*	921-4531
Major Stuart Nibeck *HQ AAC/LGX* *Elmendorf AFB, AK 99506*	________
Lt Colonel Laurence Nolte *HQ USAF/LEXY* *Washington, DC 20330*	227-4560
Colonel Richard L. Olson *HQ USAF/LEXY* *Washington, DC 20330*	227-4560
Mr. T.J. O'Malley *LMI* *4706 Sangamore Road* *Washington, DC 20016*	(202) 229-1000
Mr. Greg Opresko *Shuttle Projects Office (SP-LMO)* *John F. Kennedy Space Center* *Kennedy Space Center, FL 32899*	(305) 867-3589

USAF LOGISTICS CAPABILITY ASSESSMENT SYMPOSIUM 82

Ms. Freda W. Kurtz 785-5089
AFALD/XRSC
Wright-Patterson AFB, OH 45433

Mr. R. Warren Langley, PH. D. (303) 635-2571
R & D Associates
105 E. Vermijo
Suite 150
Colorado Springs, CO 80901

Mr. Kenneth Lavoie 424-7404
HQ USAFE
Ramstein AB, Germany

Ms. Diann Lawson 787-7939
HQ AFLC/LORA
Wright-Patterson AFB, OH 45433

Lt Colonel Leonard Lee 276-9857
1 STRAD/LGX
Vandenberg AFB, CA 93437

Ms. Joyce Lerch 430-5540
NFMSO (Code 932)
Mechanicsburg, PA 17055

Mr. Richard L. Lewis (301) 667-5471
Advanced Development Support Systems
Westinghouse Electric Corporation
1111 Schilling Road, MS 7375
Hunt Valley, MD 21030

Captain James Lowell 244-0346
AFTEC/LGL
Kirtland AFB, NM 87117

Mr. William W. Lyle 232-0232
Dept. 501
Bldg 76, Level 2
McDonnell Aircraft CO.
P.O. Box 516
Saint Louis, MO 63166

Dr. William H. Marlow (202) 676-7503
School of Engineering & Applied Science
Institute for Management Science & Engineering
The George Washington University
Washington, DC 20052

USAF LOGISTICS CAPABILITY ASSESSMENT SYMPOSIUM 82

Mr. John Greene HQ TAC/LGXS Langley AFB, VA 23665	432-4015
Captain Mark D. Greenly AFLMC/LGM Gunter AFS, AL 36114	921-4583
Colonel Richard A. Gunkel HQ AFTEC/LG Kirtland AFB, NM 87117	244-9736
Dr. Robert Hiller HQ PACAF/OA Hickham AFB, HI 96853	430-0111 449-6325
Captain Gary Hoenshell AFTEC/LG4 Kirtland AFB, NM 87117	244-0346
Mr. Stanley Horowitz Center for Naval Analysis 2000 N. Beauregard St. Alexandria, VA 22311	225-9241
Mr. Robert Howard OO-ALC/MMIRC Hill AFB, UT 84056	458-5698
Colonel Philip L. Huntwork HQ AFISC/IGBL Norton AFB, CA 92409	876-3748
Colonel Lewis Israelitt OC-ALC/MM Tinker AFB, OK 73145	735-2019
Colonel Jerry G. Jumper SA-ALC/MMM Kelly AFB, TX 78241	945-5514
Colonel John T. Koch HQ PACAF/LGX Hickam AFB, HI 96853	430-0111 449-6325

USAF LOGISTICS CAPABILITY ASSESSMENT SYMPOSIUM 82

Captain Edward Connolly *HQ MAC/LGXA* *Scott AFB, IL 62225*	638-5633
Mr. Gordon Crawford *The Rand Corporation* *1700 Main St.* *Santa Monica, CA 90406*	(213) 393-0411 X7789
Captain John T. Cunningham *HQ SAC/LGLXX* *Offutt AFB, NE 68113*	271-5496
First Lieutenant Karen Daniels *AFLMC/LGY* *Gunter AFS, AL 36114*	921-4524
Colonel Robert S. Delligatti *HQ USAF/PRPF* *Pentagon* *Washington D.C. 20330*	227-0452
Ms. Beth Forge *AFAFC/CWC* *Lowry AFB* *Denver, CO 80279*	926-7846
Captain William R. Frazier *DLA/LOO* *Cameron Station* *Alexandria, VA 22314*	284-7227
Mr. Oscar A. Goldfarb *SAFALG* *Washington, DC 20330*	227-3624
Mr. Edward Gonzales *Booze, Allan and Hamilton, Inc.* *Rutherford B. Hayes Bldg* *2361 Jefferson Davis Hwy* *Arlington, VA 22202*	(703) 979-9100 X232
Major Wayne Graybeal *104 Deer Trace* *Prattville, AL 36067*	(205) 365-9053

Major C. L. Bragaw 638-5560
HQ MAC/XPSR
Scott AFB, IL 62225

Colonel Carl K. Branan 432-7691
HQ TAC/LGX
Langley AFB, VA 23665

Lt Colonel Robert H. Brown 271-2892
HQ SAC/LGY
Offutt AFB, NE 68113

Mr. Manuel Carrillo (213) 393-0411 X7536
The Rand Corporation
1700 Main St.
Santa Monica, CA 90406

Mr. Andy Clark, PH.D. (703) 841-7800
C.A.C.I., Inc. Federal
1815 N. Fort Meyer Dr.
Arlington, VA 22209

Major Terry Clark (512) 453-5224
5504 Caprice
Austin, TX 78731

Lt Colonel Ronald W. Clarke 432-2664
HQ TAC/LGYT
Langley AFB, VA 23665

Mr. James Cohick 977-6848
US Army Logistics Evaluation Agency
(DALO-LEP)
NCAD
New Cumberland, PA 17070

Mr. Michael L. Collier 787-2622
HQ AFLC/XRPEA
Wright-Patterson AFB, OH 45433

Mr. Terence Colvin, PH.D. (202) 232-6261
Synergy, Inc.
2337 18th St. N.W.
Washington, DC 20009

USAF LOGISTICS CAPABILITY ASSESSMENT SYMPOSIUM 82

PARTICIPANTS

Major William D. Arnold *HQ TAC/LGSW* *Langley AFB, VA 23665*	432-4768
Mr. Dan Barker *HQ TAC/XPM* *Langley AFB, VA 23665*	432-3292
Captain John Bauman *USAFA/LGSP* *USAF Academy, CO 80840*	259-2875
Colonel George D. Benjamin *SA-ALC* *Kelly AFB, TX 78241*	945-7151
Mr. Mort Berman *The Rand Corporation* *1700 Main St.* *Santa Monica, CA 90406*	(213) 393-0411 X7846
Dr. Authella Bessent *University of Texas* *School of Business* *Austin, TX 78712*	(512) 471-3322
Dr. Wailand Bessent *University of Texas* *School of Business* *Austin, TX 78712*	(512) 471-7551
Dr. Jim Bigelow *The Rand Corporation* *1700 Main St.* *Santa Monica, CA 90406*	(213) 393-0411
Major James Blanchard *TACOPS/DOCR* *Langley AFB, VA 23665*	432-3349
Captain Daniel L. Bloomer *OO-ALC/MAKEM* *Hill AFB, UT 84056*	458-4781

USAF LOGISTICS CAPABILITY ASSESSMENT SYMPOSIUM 82

OFFICIALS

CONVENER	Major General Theodore D. Broadwater Director, Logistics Plans and Programs DCS/Logistics and Engineering Headquarters, United States Air Force Washington, D.C. 20330
CHAIRMAN	Brigadier General William P. Bowden Deputy Director, Logistics Plans and Programs DCS/Logistics and Engineering Headquarters, United States Air Force Washington, D.C. 20330
VICE CHAIRMAN	Lt Colonel Joseph M. Campbell (Col Selectee) Dep Div Chief, Logistics Concepts Division D/Logistics Plans and Programs Headquarters, United States Air Force Washington, D.C. 20330
EXECUTIVE SECRETARY	Major Douglas D. Cochard Chief, Management Sciences Division Air Force Logistics Management Center Gunter Air Force Station, AL 36114
ADMINISTRATIVE SECRETARY	Deborah S. Ludlow Logistics Concepts Division Headquarters, United States Air Force Washington, D.C. 20330

SECTION [illegible]

Names of Participants, Organizations
and Telephone Numbers

Note: 7-digit numbers shown are Autovon, Commercial numbers are 10-digit with the area code in parentheses

This disagreement is likely even when the requirements system and the assessment system use the same criterion (which they are now approaching). This is due to different scenarios, specific beddowns, assumptions, etc. This is particularly true when dynamic wartime scenarios are being evaluated, in a real contingency, and resourcing decisions to tie the depot to the field must be made. Our central systems are not built to cope with these situations.

What is needed is an organizational framework which allows the coexistent use of assessment tools and central resourcing models. We must have organizations to exercise assessment tools in dynamic conflict and we must provide for a systematic way in which decentralized evaluations of the central models (check and balance) can find their way into the decision making process. One way, and only one way, is to make provisions for these assessments to find their way into the POM - perhaps in an enhanced line. The point is this information can and should be used to make marginal improvements to the requirements process.

To sum up, capability assessments need not and should not be constrained by the same constraints imposed on the requirements models. Capability assessments need to open up requirements assumptions and evaluate specific alternatives not considered in the requirements computation process. Given problems are uncovered, we need to input these evaluations and enhance our resourcing and policy decisions. To do this we need to structure organizations which are independent from the requirements process and yet have methods of influencing requirements resourcing, albeit perhaps on the margin.

That concludes my remarks. What I hoped to do was to lay out a roadmap of the research that needs to be done in the next 5 to 10 years. We need to develop the tools necessary to assess logistics support - vertically and horizontally - in terms of combat effectiveness. We need to create organizational settings to use these tools. In short, we need to develop the tools and organizations necessary to tailor the support structure to provide the greatest combat effectiveness for the resources we have. We must do it, we can do it. I challenge you to work with me to bring it about.

I'm not sure if these vertical and horizontal integration issues are separable as I've chosen to talk about them. You need to think about these matters. What I've tried to do, so far, is outline the areas I think you need to be working to move this technology to places where it can be truly productive.

Before I sum up, I want to address the importance of the organization setting we need to develop to really put these tools to good use. We have to overcome two significant problems in this area. The first deals with staffing and the second deals with structuring organizations that can deal with the "heat" caused by evaluating and challenging the current ways of doing business. Let's talk to the staffing issue first.

The birth and use of these tools have tremendous implications for our personnel folks. In our working organizations we need to develop analytically oriented people who know how to interpret the data going into and coming out of the assessment techniques. These people also need to know enough about the guts of these models. We can't afford to have people conducting these assessments who don't understand the tools used or the areas they are assessing. We just don't have enough people with analytical skills who work these planning and programming actions in their areas of responsibility. We need to grow them. So we have a tremendous education problem. You need to be thinking about the skill levels needed to operate these tools and how we can develop education programs to move us in that direction.

Let me give you a concrete example of what I'm talking about in this area. As some of you know, we've just recently started asking our system managers to make spares assessments of the aircraft in terms of combat measures for different scenarios. To accomplish these assessments requires people familiar with the WRSK/BLSS/POS requirements and reporting systems. They also need to understand the assessment technique. They also need some capability of using the computer. Finally, they need analytical orientations to look at the system-wide impacts of their assessments and to trouble shoot the problems uncovered in their analyses. We have precious few folks with these skills. The same is true in the other MAJCOMs. This problem will be compounded when we expand into other resource evaluations. We need to develop training programs now.

An even more difficult issue to deal with involves structuring the organizational framework and communications required to use the data generated from these models to influence decisions. If we are to conduct assessments addressing base-depot and multi-theater operations on a specific unit basis, some disagreement or conflict with the central requirements systems may be inevitable.

papers discussed the recent developments in Dyna-Metric which has tied the base and depot system together to examine spares, repair, and transportation impacts on combat effectiveness. The point is we are developing the techniques to attack these interrelated system problems. But we need to go a lot further. We need to expand the resources and processes covered.

Here are some of the specific questions we need answers to. Do we have adequate resources at the bases and depots to support the scenario in question? What are forecasted combat impacts of spares, support equipment, munitions, and TRAP shortages. How do depot and base level constraints in repair and transportation capability impact combat effectiveness? How do depot and base level support policies impact combat effectiveness? What are the critical resources? Are we sized to do the job? Again my point is we can no longer afford to treat the base and depot as separate systems. They interact to impact combat effectiveness. We must know how they interact. I challenge you to help build the tools necessary to evaluate our current plans and help improve our support to the front line.

Let's turn our attention now on what needs to be done in the "horizontal" assessment area. We need to be able to quantitatively assess the impacts of multi-theater operations on combat effectiveness. Today, most of our efforts are spent on evaluating single theater or single unit war plans. USAFE and PACAF concentrate their efforts on their particular scenarios. TAC examines specific unit wartime capabilities due largely to their notional tasking. Don't get me wrong! I'm not knocking any of this work; some of it is very good and represents real breakthroughs. The work Lt Col Clarke and his folks have done at TAC is really tremendous and should be singled out for praise. We just need to go further.

We need to know how multiple theater scenarios affect support requirements. We need to know how colocating forces and resources impact combat effectiveness. If we have shortages in one theater or set of bases, can colocated forces cover for one another while we use some of their resources to cover the shortages in other bases? Are there shortages in one theater but overages elsewhere? How would a redistribution of assets in one theater impact combat effectiveness of both? Where should we concentrate transportation, resupply, and repair action? How fast and for what resources do we need to increase the velocity of our pipeline actions?

My major point here is that we can no longer develop OP plans on single front information. We need to know how multiple theaters of operations impact one another in terms of logistics resources. In short, we need to link multi-theater actions to support actions and plans. And we in AFLC have a very tough problem - let me explain.

Don't mistake my intent here! We still have a long way to go in modeling before we are able to capture it's full potential. We still have too many modelers isolated from the organizations trying to cope with problems. We are still attacking functional problems without enough attention to interfaces between the functions. We are still attacking base or depot level problems without linking the two systems. We are still oriented toward analyses in one theater instead of looking at worldwide impact. And we are still not connecting our models and resourcing decisions at each vertical level in our decision hierarchy to combat effectiveness.

My point here is that while we may wish to select particular techniques to use for consistency, we will never reach the point where we can stop improving our models. So while we may wish to freeze a design to use for some period, we want to have mechanisms to encourage initiative to keep better designs coming into the system.

While there are plenty of hurdles to overcome in bringing this off, the main thrust of my remarks are geared to laying out a challenge for you to develop vertically and horizontally integrated assessment techniques. I also want to challenge you to develop ideas on organizational approaches that would be workable to harness this capability.

Let's talk for a few minutes on what we need in "vertical" assessment tools. We need more than ever before to know how the base or field level logistics system interacts with the depot level system. The systems are too often treated as isolated spheres when, in fact, they interact in very specific and important ways. Let me give you an example of how I visualize this interaction. Let's say we have a fight on our hands in some part of the world. In this conflict some of our bases near the FEBA get clobbered and they lose most of their maintenance capability. We need to know or estimate which spares need to be pushed to the theater. We need to know how important depot repair is on what sets of items so we can lay plans to increase the "velocity" of repair or transportation pipelines for those assets.

We should have the tools necessary to tell us how important these interactions are for various resources in terms of combat effectiveness. We need to know this so we can size our depot level plant structure to meet combat needs. We need this data to lay out logistics battle plans. Just in case this sounds like "pie in the sky" kind of thinking to some of you, let me give you a couple of illustrations of how far we've come in this area.

Several of the papers at this Symposium addressed how depot level resupply can impact theater level sortie generation. Other

USAF LOGISTICS CAPABILITY ASSESSMENT SYMPOSIUM 82

Lt Colonel John Wilhelm *HQ PACAF/OAC* *Hickam AFB, HI 96853*	430-0111 449-6325
Lt Colonel Harold Williams *HQ AFLC/LOA* *Wright-Patterson AFB, OH 45433*	787-7033
Flight Lieutenant Dave Wilson *HQ TAC/LGSW* *Langley AFB, VA 23665*	432-4016
Mr. Donald Zimmerman *Synergy, Inc.* *2337 18th St. NW* *Washington, DC 20009*	(202) 232-6261
Mr. Oscar Rausch US Army Logistics Evaluation Agency DALO-LEP, NCAD New Cumberland, PA 17070	977-6848
Mr. Brian Esterby 8066 S. Rosemary Ct Englewood, CO 80112	(303) 977-7267
Ms Debbie Ludlow HQ USAF/LEXY Pentagon Washington, D.C. 20330	227-4560
Major William H. Campbell HQ USAF PRPFS Pentagon Washington, D.C. 20330	227-4131
Captain Paul Needham HQ USAF/LEXY Pentagon Washington, D.C. 20330	227-4560